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NATIONAL MUSEUM OF CANADA

Bulletin No. 172

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CONTENTS

	PAGE
New records of beach hoppers (Crustacea: Amphipoda) from the coast of California, by E. L. Bousfield.....	1
Amphipod Crustaceans of the Pacific Coast of Canada, I. Family Atylidae, by Eric L. Mills.....	13
Fish remains from a 600-year-old St. Lawrence River Iroquois site, by D. E. McAllister.....	34
A collection of oceanic fishes from off British Columbia with a discussion of the evolution of black peritoneum, by D. E. McAllister.....	39
The origin and status of the deepwater sculpin, <i>Myoxocephalus thompsonii</i> , a nearctic glacial relict, by D. E. McAllister.....	44
Systematics of the freshwater sculpins (<i>Cottus</i>) of British Columbia, by D. E. McAllister and C. C. Lindsey.....	66
Biological investigations at Isachsen, Ellef Ringnes Island, N.W.T., by S. D. MacDonald.....	90
Notes on Newfoundland birds, by W. Earl Godfrey.....	98
Notes on Canadian mammal specimens and types in the British Museum (Natural History), London, by A. W. F. Banfield.....	112
Notes on the mammals of the Kluane Game Sanctuary, Yukon Territory, by A. W. F. Banfield.....	128

Illustrations

	PAGE
<i>Paper No. 1—</i>	
Figure 1. <i>Parorchestia klawei</i> n. sp. and <i>Orchestia traskiana</i>	4
2. <i>Parorchestia klawei</i> n. sp. and <i>Orchestia traskiana</i>	6
3. <i>Orchestoidea pugettensis</i> (Dana).....	8
4. <i>Orchestoidea corniculata</i> Stout, <i>O. columbiana</i> Bousfield, and <i>O. minor</i> Bousfield.....	10
<i>Paper No. 2—</i>	
Figure 1. <i>Atylus levidensus</i> Barnard. Whiffen Spit, Sooke, V.I., B.C.....	21
2. <i>Atylus collingi</i> (Gurjanova). Oyster Bay, V.I., B.C.....	24
3. <i>Atylus tridens</i> (Alderman). Non-pelagic—southeast end Wickaninnish Bay, V.I., B.C.....	27
4. Occurrences. (A) <i>Atylus levidensus</i> . (B) <i>A. collingi</i> . (C) <i>A. tridens</i>	29
<i>Paper No. 3—</i>	
Figure 1. a-d. Various aspects of <i>Esox</i> sp.....	35
2. a. Posterior surface of right pharyngeal arch of <i>Catostomus comersonii</i>	37
b. Posterior surface of right pharyngeal arch of <i>Catostomus catostomus</i>	37
c. External surface of left preopercle of <i>Perca flavescens</i>	37

	PAGE
<i>Paper No. 5—</i>	
Figure 1. Preopercular spine length plotted against standard length in <i>Myoxocephalus thompsonii</i> and <i>M. quadricornis</i>	48
2. Lateral view of head of <i>Myoxocephalus quadricornis</i> showing spines....	49
3. The distribution of <i>Myoxocephalus thompsonii</i> and <i>M. quadricornis</i> in North America, the extent of marine invasions, and numbered lakes...	59
<i>Paper No. 6—</i>	
Figure 1. Dorsal view of heads of (A) <i>Cottus ricei</i> , (B) <i>C. cognatus</i>	68
2. Meristic variation in specimens of <i>Cottus</i> examined from British Columbia.....	70
3. Prickle form in British Columbia species of <i>Cottus</i> , drawn from stained and cleared specimens.....	71
4. Areas of prickling in <i>Cottus asper</i>	72
5. Distribution of morphological characters in <i>Cottus cognatus</i>	78
<i>Paper No. 10—</i>	
Figure 1. Distribution of white sheep in the Kluane Sanctuary.....	133

NEW RECORDS OF BEACH HOPPERS (CRUSTACEA: AMPHIPODA) FROM THE COAST OF CALIFORNIA

By E. L. BOUSFIELD

During the period July 2 to 12, 1959, collections of terrestrial amphipod crustaceans were made at selected localities along the Pacific coast of California, from Crescent City on the north to San Diego on the south. This material has been supplemented by specimens from the San Diego and La Jolla region, kindly donated by Dr. W. L. Klawe and Dr. W. D. Clarke of the Scripps Institute of Oceanography, and by specimens from the Los Angeles area that were made available by Dr. T. E. Bowman, United States National Museum. Distributionally critical lots of material, collected in 1959 along the northern and central coasts of the state by Dr. Darl E. Bowers, Mills College, Oakland, are herewith gratefully acknowledged.

The material contains one new species, *Parorchestia klawei*, from the San Diego region. Significant range extensions are noted; southward in *Orchestoidea pugettensis* (N. California to Pt. Sur), *O. columbiana* (British Columbia to Monterey Peninsula), and *Orchestia georgiana* (British Columbia to S. California), and northward in *Orchestoidea corniculata* (Monterey Peninsula to Trinidad Head), and *O. benedicti* (Dillon Beach to Crescent City). Further records of *Hyale plumulosa*, *Orchestia traskiana*, *Orchestoidea californiana*, and *Talitroides pacificus* are given.

KEY TO SPECIES

1. Antenna 1 longer than peduncle of antenna 2; telson cleft to base.....*Hyale*
Lower margin of antenna 2 lined with tufts of fine setae....*H. plumulosa* (Stimpson)
Antenna 1 shorter than peduncle of antenna 2; telson notched at tip or entire.... 2
2. Uropod 1 with conspicuous inter-ramal spine; Mxpd palp with small 4th (terminal) segment; pleopod 3 noticeably smaller than pleopods 1 and 2 (Fig. 1)..... 3
Uropod 1 without conspicuous inter-ramal spine; Mxpd palp appearing 3-segmented, or with minute 4th segment; pleopods subequal (Fig. 1, 3)..... 4
3. Gnathopod 1 subchelate; gnathopod 2 powerfully subchelate in male, weakly chelate (mitten-like) in female.....*Parorchestia*
Pleopod 3 only $\frac{2}{3}$ length of pleopods 1 and 2; peduncle of uropod 3 broad, with 5 stout spines along upper margin.....*P. klawei* n. sp.
Gnathopod 1 simple; gnathopod 2 weakly chelate (mitten-like) in both sexes.*Talitroides*
Pleopod 3 vestigial, stump-like; inter-ramal spine with terminal spur and accessory blade.....*T. pacificus* Hurley
4. Gnathopod 1 weakly subchelate, lightly spinose; uropod 3, ramus tapering to a point, with few spines; segment 6 shorter in peraeopod 4 than in peraeopod 5; pleopods normal (Fig. 1).....*Orchestia* 5
Gnathopod 1 simple, heavily spinose; uropod 3, ramus rounded at tip, not tapering, heavily spinose; pleopods short, weakly plumose, peduncles spinose; segment 6 longer in peraeopod 4 than in peraeopod 5 (Fig. 3).....*Orchestoidea* 6

5. Rami of pleopods 9- to 10- segmented, about equal in length to peduncles; gnathopod 1 (in male) with small blister on lower margin of segment 4 (Fig. 1).....*O. traskiana* Stimpson
 Rami of pleopods 5- to 7- segmented, about $\frac{2}{3}$ the length of the peduncles; gnathopod 1 (in male) without small blister on segment 4.....*O. georgiana* Bousfield
6. Uropod 2, inner margin of outer ramus without lateral spines; antenna 2, flagellum shorter than peduncle..... 9
 Uropod 2, inner margin of outer ramus bearing lateral spines; antenna 2, flagellum not shorter than peduncle, usually much longer (esp. in male)..... 7
7. Margins of abdominal side plates armed with numerous small spines; gnathopod 1 (in female) with pellucid process on lower margin of segment 5.....*O. californiana* (Brandt)
 Margins of abdominal side plates smooth or nearly so; gnathopod 1 (in female) without pellucid process on segment 5..... 8
8. Outer ramus of uropod 2, spines on *inner* margin extend beyond spines on *outer* margin (Fig. 4k); thoracic segment 7 with conspicuous dorsal pigmentation pattern.....*O. minor* Bousfield
 Outer ramus of uropod 2, spines on *outer* margin extend beyond those on *inner* margin (Fig. 4h); thoracic segment 7 lacking conspicuous dorsal pigmentation pattern.....*O. columbiana* Bousfield
9. Telson notched at tip; abdominal side plate 1 with 1 to 7 spines on antero-ventral margin; gnathopod 1 (of male) with conspicuous blister on lower margin of segment 6, near base of claw (Fig. 3g).....*O. pugettensis* Dana
 Telson pointed at tip; abdominal side plate 1 with smooth antero-ventral margin; gnathopod 1 (of male) without conspicuous blister on segment 6..... 10
10. Posterior margins of abdominal side plates armed with 10 or more small spines; mature animals large (15 to 22 mm) (Fig. 4c).....*O. corniculata* Stout
 Posterior margins of abdominal side plates with 1 to 5 small spines; mature animals small (9 to 13 mm).....*O. benedicti* Shoemaker

SYNOPSIS OF THE SPECIES

Family TALITRIDAE Stebbing 1906
 (=superfamily TALITROIDEA Bulycheva 1957)

1. *Hyale plumulosa* Stimpson 1854

Material Examined:

Rolph, Humboldt Co., hiding in bark of washed up log, E.L.B., July 3/59—10 males, 9 females (ovig.).

Mission Bay, San Diego, under driftwood in salt marsh, Mar. 26/59, W. L. Klawe coll.—5 males, 3 females (2 ovig.).

East shore Tierra del Fuego I., Mission Bay area, San Diego, W. D. Clarke, June 3/56—1 female.

Remarks. This species and the "saddle-back" hopper (*H. pugettensis*) of upper rock pools have the typically aquatic body form, i.e. possessing long first antennae, large coxal gills, and strong pleopods; yet they are able to hop about actively amongst damp debris in the tidal zone. *Hyale plumulosa* ranges north to the Queen Charlotte Islands, B.C., in estuaries and brackish water areas that are warm in summer.

2. *Orchestia traskiana* Stimpson 1857

(Figures 1, 2)

Material Examined:

Crescent City, Del Norte Co., fine sand, at HW, E.L.B., July 2/59—1 male, 1 female, 1 imm.

Rolph, Humboldt Co., sand at HW, E.L.B., July 3/59—1 male.

Baker's Beach, San Francisco, HW level, base of cliff, E.L.B., July 4/59—6 males, 4 females (ovig.).

Shell Beach, San Luis Obispo Co., under debris on gravel, E.L.B., July 10/59—1 female imm.

Mission Bay, San Diego, under drift in salt marsh, March 26/59—2 males, 2 females (ovig.).

East shore Tierra del Fuego I., Mission Bay area, San Diego, W. D. Clarke, June 3/56—5 males, 4 females, 1 juvenile.

Ocean Beach, San Diego, on algal mats at HW level, E.L.B., July 7/59—10 males, 8 females, 33 juveniles.

Pt. Loma, San Diego, rocky shore above HW level, W. L. Klawe, Apr. 15/56—1 male, 2 females (ovig.).

Remarks. *O. traskiana* and the following species are close to the ancestral aquatic type (e.g. *Hyale*) in possessing short, stout, unmodified peracopods and uropods, partly cleft telson, large brood plates, and "hooked" brood-plate setae. Material of *O. traskiana* from southern California is somewhat smaller, more slender, less spinose, and basos of peraeopods less serrulate than from northern California and northwards.

3. *Orchestia georgiana* Bousfield 1958

Material Examined:

Ocean Beach, San Diego, under washed-out weeds, rocky shore, W. L. Klawe, Feb. 2/56.—3 females.

Pt. Loma, San Diego, rocky shore above HW level, W. L. Klawe, Apr. 15/56—1 male.

East shore Tierra del Fuego I., Mission Bay area, San Diego, W. D. Clarke, June 3/56—3 males, 4 females (ovig.), 1 mm.

Remarks. These records (the first outside the Canadian Pacific region) suggest that *O. georgiana* is a southern species with a relict northern population in the "warm-water" Strait of Georgia region and might be expected in intervening localities where summer conditions are suitable.

4. *Parorchestia klawei* n. sp.

(Figures 1, 2)

Description. Male (16.5 mm.): Head as deep as long. Eye medium, dark, subrotund. Antenna 1, flagellum of 7 or 8 short segments, equal in length to peduncle, tip extending to segment 5 (outer) of peduncle of antenna 2. Antenna 2 rather slender, geniculate, flagellum of 20 to 24 segments, each with a distal whorl of stiff setae.

Mouthparts typical. Mandible, cutting edge with 6 teeth and lacinia with 5. Maxilla 1, outer plate with 9 apical pectinate spine teeth; palp minutely 2-jointed; inner plate with stout apical and subapical plumose setae. Maxilliped inner plate with 3 apical spine teeth; palp 4-segmented, 4th joint very small, 2nd segment very broad with median distal expansion.

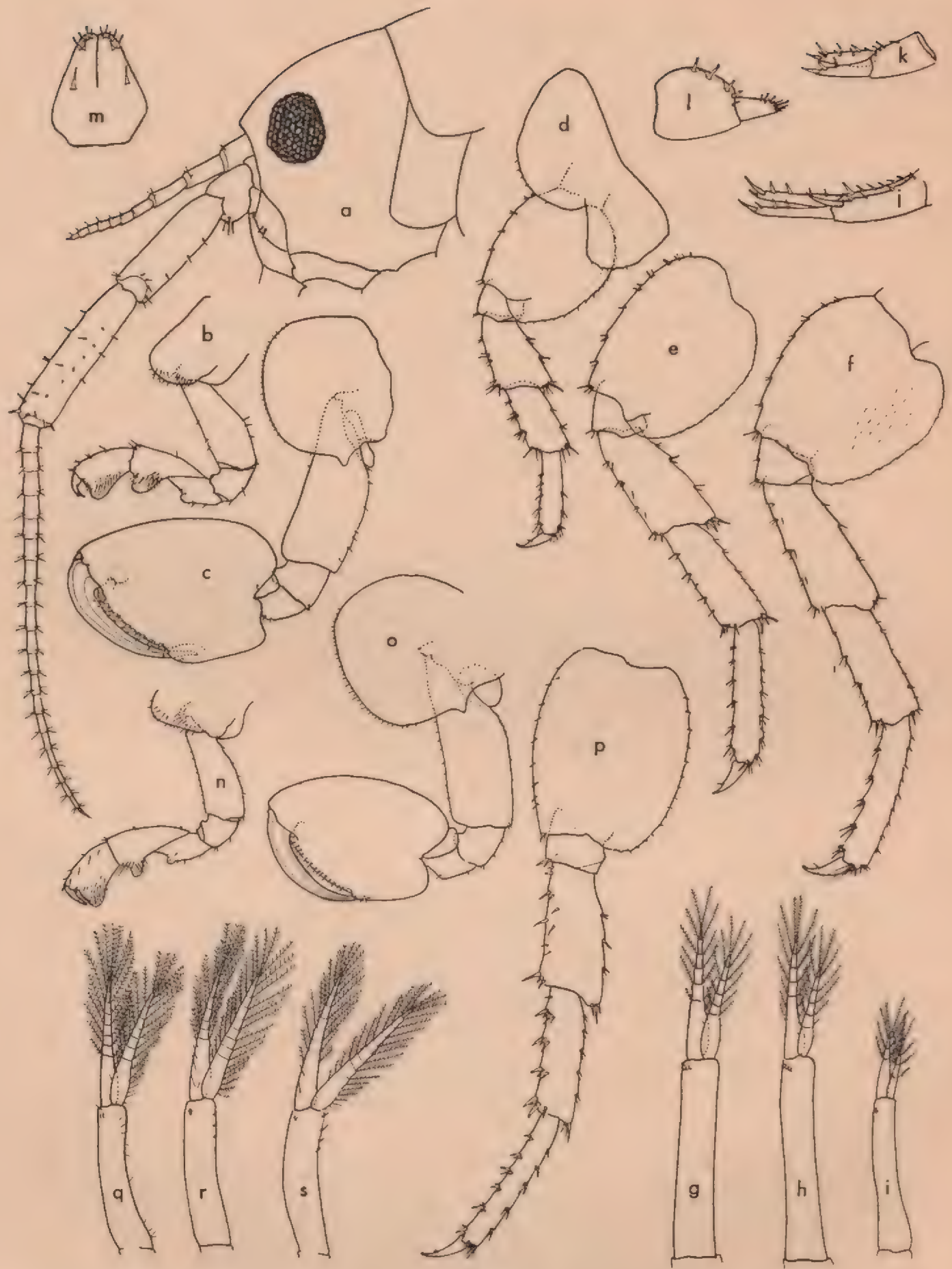


FIGURE 1. *Parorchestia klawei* n. sp., Ocean Beach, San Diego. Male (16.5 mm) Type: (a) head and antennae, (b) gnathopod 1, (c) gnathopod 2, (d) peraeopod 3, (e) peraeopod 4, (f) peraeopod 5, (g) pleopod 1, (h) pleopod 2, (i) pleopod 3, (j) uropod 1, (k) uropod 2, (l) uropod 3, (m) telson. *Orchestia traskiana* Stimpson, Tierra del Fuego I., San Diego. Male (15 mm): (n) gnathopod 1, (o) gnathopod 2, (p) peraeopod 5, (q) pleopod 1, (r) pleopod 2, (s) pleopod 3.

Gnathopod 1, weakly subchelate; dactyl short, not reaching beyond "blister" on lower margin of segment 6; segments 4 and 5 each with "blisters" on lower margin. Gnathopod 2, powerfully subchelate; segment 6 (propodus) with oblique, regularly convex palm, lined with stout spine teeth, lower margin nearly straight, produced distally into a lobe at the palmar angle, on the inside of which is a groove for the reception of the slender recurved tip of the tightly closing dactyl.

Peraeopod 1 a little larger than 2, each with short simple dactyl. Peraeopods 3 to 5 stout, lightly spinose, successively larger; basos in each is moderately expanded, posterior border finely serrulate. Small sac-like coxal gills on gnathopod 2 and peraeopods 1 to 4.

Abdominal side plates 1 to 3, lower margins almost smooth, posterior border finely serrulate, hind corner not produced. Pleopods slender, rami much shorter than the peduncles, inner ramus longer than outer. Pleopods 1 and 2 subequal, slender; rami 5- or 6-segmented; peduncles slender, smooth, each with 4 coupling spines near inner distal angle. Pleopod 3 only two-thirds the length of 1 and 2; rami 4-segmented; peduncle about twice the rami, with 3 coupling spines.

Uropod 1, both rami armed with lateral spines; peduncle distally with simple but prominent inter-ramal spine. Uropod 2, both rami spinose. Uropod 3, peduncle expanded, with 4 or 5 cleft-tipped spines on upper margin; ramus shorter, tapering, with several spines at blunt apex.

Telson spade-shaped, longer than broad, apex slightly cleft; upper surface with a pair of prominent spines about midway and groups of spines near apex. Female (12 to 15 mm): Antenna 2 shorter and with fewer segments. Gnathopod 1 weakly subchelate, tip of dactyl extending beyond lower angle of short, vertical palm; segments 4 and 5 without "blisters" on lower margin. Gnathopod 2 minutely chelate or "mitten-like"; segment 2 long and narrow, front margin scarcely at all expanded; segment 4 with shallow "blister" on lower margin. Brood plates rather short and narrow, tips of marginal setae are finely pointed, not hooked.

Material Examined:

East side Tierra del Fuego I., Mission Bay, San Diego, W D. Clarke, June 3/56—1 male.

Ocean Beach, San Diego, under washed-out weeds, W. L. Klawe, April 15/56—Male, type (16.5 mm); female allotype (13.0 mm, ovig.); 4 males, 6 females, 1 juvenile, paratypes. NMC No. 2280.

San Clemente I., T. L. Casey coll., U.S.N.M. Acc. No. 50326.—2 males (18 mm), 2 females (ovig.).

Remarks. This species belongs in the group of *Parorchestia marquesana* Stephensen (figured by Shoemaker 1942 from Clipperton Island) and *P. tenuimana* Iwasa 1938 (Japan) having partially reduced pleopods, broad maxpd palp, expanded peduncle of third uropods, and notched telson. *P. klawei* differs from these in having pleopods less strongly reduced, telson less deeply cleft, basos of peraeopod 5 more broadly expanded, and peduncle of uropod 3 with more marginal spines.

Distribution. Known only from extreme southern California, including the offshore island of San Clemente, but probably extending well down the coast of Mexico.

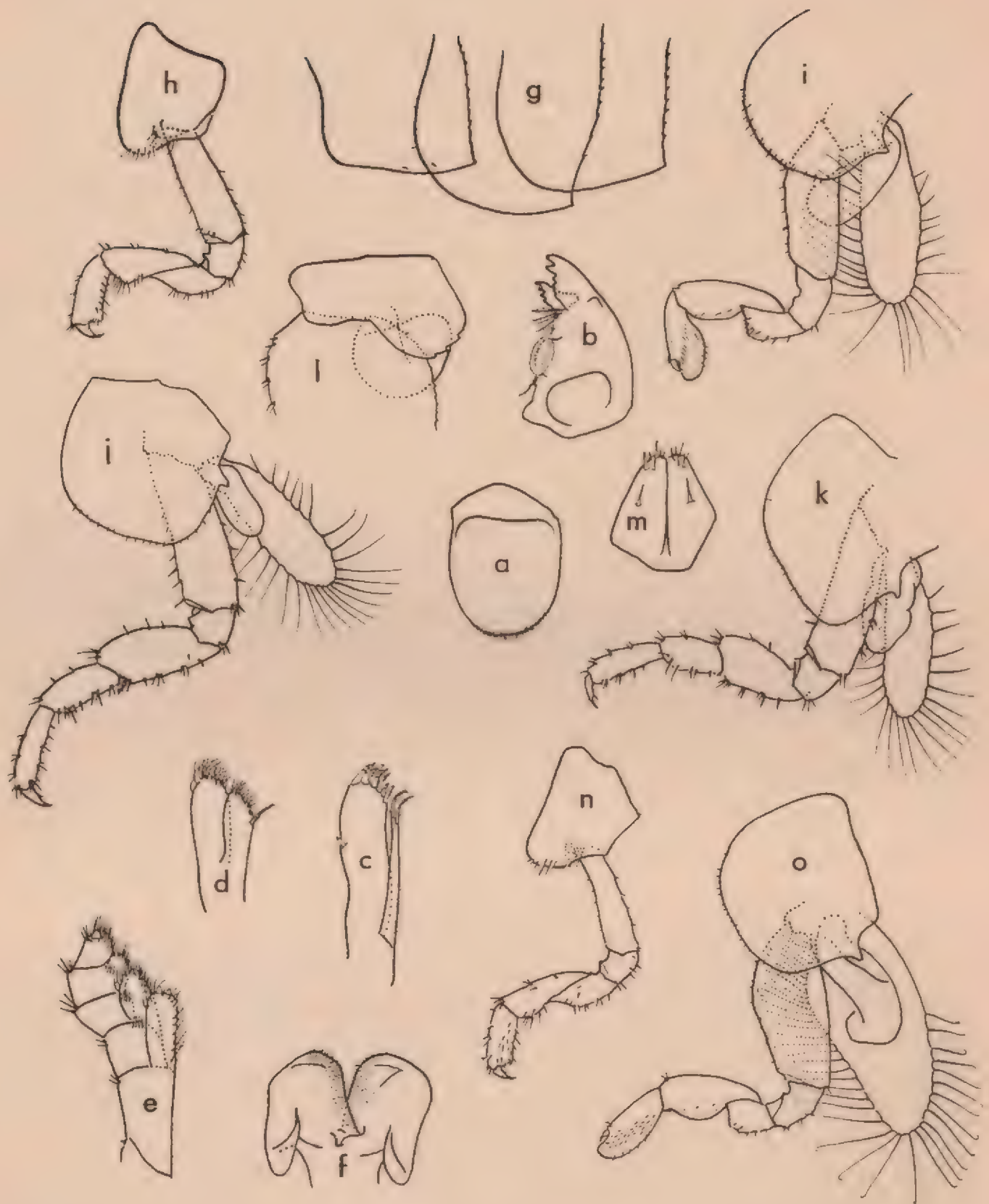


FIGURE 2. *Parorchestia klawei* n. sp., Ocean Beach, San Diego. Male (16.5 mm) Type: (a) upper lip, (b) mandible, (c) maxilla 1, (d) maxilla 2, (e) maxilliped, (f) lower lip, (g) abdominal side plates 1 to 3. Female (13 mm) allotype: (h) gnathopod 1, (i) gnathopod 2, (j) peraeopod 1, (k) peraeopod 2, (l) peraeopod 4, (m) telson. *Orchestia traskiana* Stimpson, Tierra del Fuego I., San Diego. Female (13 mm): (n) gnathopod 1, (o) gnathopod 2.

5. *Talitroides pacificus* Hurley 1955.

Material Examined:

Los Angeles, L. A. Co., under ivy in dooryard, R. H. Smith, Mar. 10/48. U.S.N.M. Acc. 170033.—8 females (ovig.) (9.5 to 12 mm).

Remarks. This species was probably introduced in California during extensive importation of Eucalyptus trees and other plants from Australia (Hurley, 1955). Though native to Australia, it is presently known from a great many Indo-Pacific islands, including the Hawaiian Islands.

6. *Orchestoidea pugettensis* (Dana) 1853

(Figure 3)

Material Examined:

Beach at mouth of First Creek, north of Jenner, 2 miles above Sonoma Co., D. E. Bowers, Sept. 8/59.—10 males, 4 females.

Beach just south of Miramonte Pt., San Mateo Co., D. E. Bowers, July 28/59—4 males, 12 females.

Petticoat Beach, near Carmel, Monterey Co., E.L.B., July 5/59—12 subadult males, 33 females, 4 juveniles.

Beach 9.3 miles north of Pt. Sur, Monterey Co., D. E. Bowers, Aug. 13/59—1 male, 14 females.

Remarks. Although originally recorded by Dana from Puget Sound and subsequently redescribed by Stebbing (as *Talorchestia tridentata*) from northern California, these are the first specified locality records from south of the Puget Sound region. Specimens from the Monterey region (the known southern limit) differ in several characters from those of British Columbia and other northern regions. The most obvious difference is the near absence of spines on the antero-ventral margin of abdominal side plate 1 and lower margin of side plate 3 which are fairly spinose in the north (Fig. 3n, 3w). The development of the double prominence at the palmar angle of gnathopod 2 in the male is delayed until a late instar, and the palm is more convex in the Monterey material (Fig. 3h, 3v). The specific (or subspecific) recognition of these and other differences would require examination of a geographically adequate series of specimens from the American Pacific coast.

Taxonomically, *O. pugettensis* is distinguished (in the male) by the prominent "blister" distally on the lower margin of segment 6 of gnathopod 1, forming a "pseudopalm" at its apex, against which the base of the dactyl closes; the appendage thus appears almost subchelate. This species is more diurnal than *O. corniculata* and *O. benedicti* and is more frequently found hiding under debris rather than burrowing deeply in the sand. A good field mark is the presence of conspicuous horizontal dark bars (lacking in species below) on either side of pereon segments 5, 6, and 7, just above the coxal plates.

7. *Orchestoidea corniculata* Stout 1913

(Figure 4)

Material Examined:

Trinidad Head, Humboldt Co., D. E. Bowers, Sept., 1959—4 specimens (pers. comm.).

Van Damme Beach State Park, Mendocino Co., black sand at HW, D. E. Bowers, Sept. 9/59—6 males, 2 females.

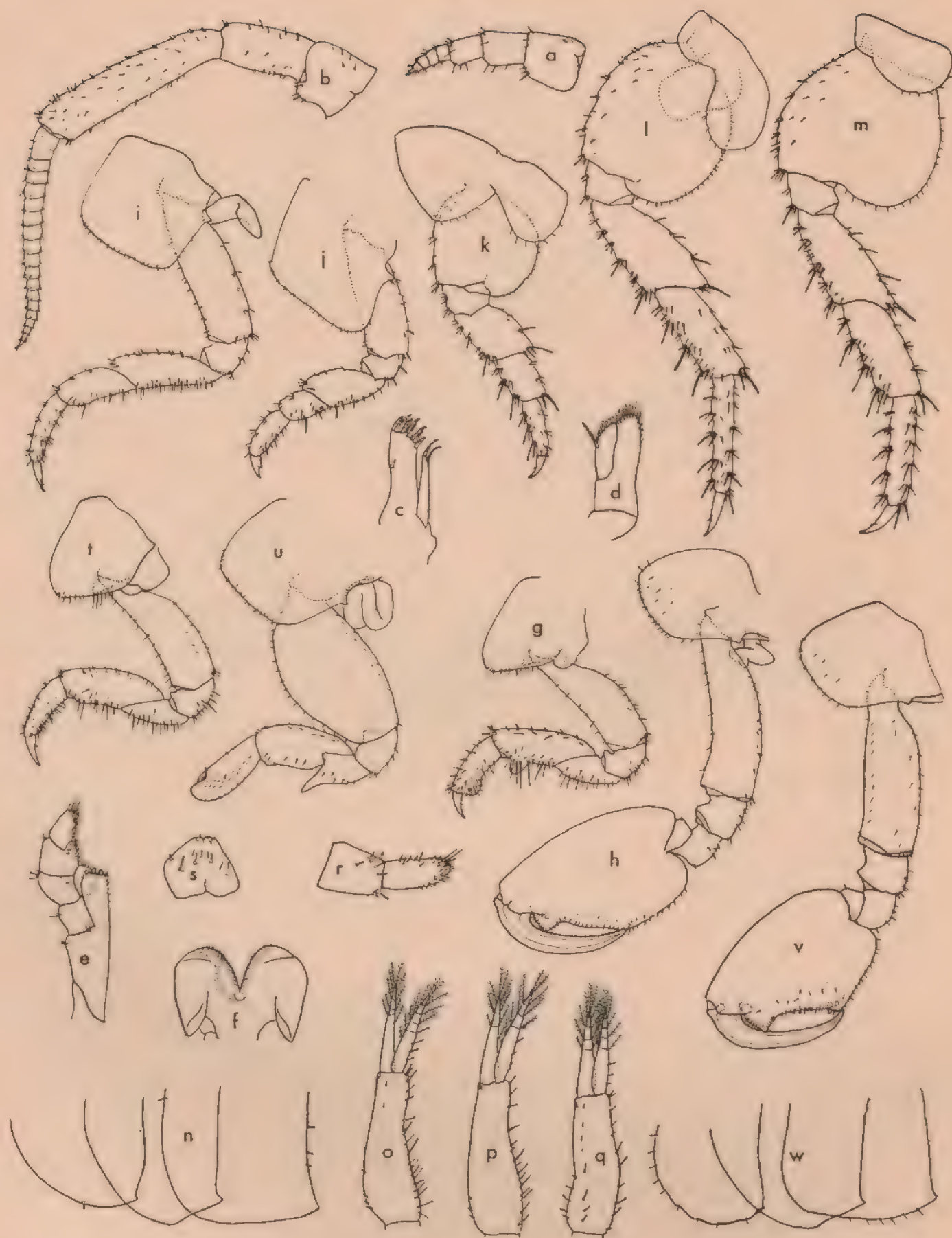


FIGURE 3. *Orchestoidea pugettensis* (Dana), Petticoat Beach, Monterey Co. Male (13.5 mm): (a) antenna 1, (b) antenna 2, (c) maxilla 1, (d) maxilla 2, (e) maxilliped, (f) lower lip, (g) gnathopod 1, (h) gnathopod 2, (i) peraeopod 1, (j) peraeopod 2, (k) peraeopod 3, (l) peraeopod 4, (m) peraeopod 5, (n) abdominal side plates 1 to 3, (o) pleopod 1, (p) pleopod 2, (q) pleopod 3, (r) uropod 3, (s) telson. Female (12 mm): (t) gnathopod 1, (u) gnathopod 2. *O. pugettensis*, Victoria, B.C., male (13 mm): (v) gnathopod 2, (w) abdominal side plates 1 to 3.

Tomales Pt., just south of McClure's Beach, Marin Co., D. E. Bowers, Sept. 10/59—6 males, 2 females.

Monterey Boat Works, just south of Hopkins Marine Station, Pacific Grove, Monterey Co., D. E. Bowers, July 1/59—5 males, 3 females (ovig.).

Shell Beach, San Luis Obispo Co., coarse sand at base of cliff, E.L.B., July 10/59—2 males, 15 females (6 ovig.), 20 juveniles.

Ocean Beach, San Diego, on sand at base of cliff, E.L.B. and W. L. Klawe, July 7/59—33 males, 41 females, numerous juveniles.

Remarks. The record of *O. corniculata* at Trinidad Head is a considerable northward extension of its previously known limit at Monterey. This species is well adapted for digging in sand, as shown by its very powerful first gnathopods and robust spinose appendages. In the male, segment 6 of gnathopod 1 is virtually without "blister" on the lower margin; the "blister" on segment 5 is small (Fig. 4a).

8. *Orchestoidea benedicti* Shoemaker 1930

Material Examined:

Crescent City, Del Norte Co., fine sand at HW, E.L.B., July 2/59—1 male, 1 female.

Rolph, Humboldt Co., fine sand, E.L.B., July 3/59—1 male.

Palm Beach, near Watsonville, Santa Cruz Co., D. E. Bowers, July 17/59—4 males, 8 females.

Morro Strand Beach, N. end, San Luis Obispo Co., E.L.B., July 5/59—8 males, 2 females.

Solana Beach, San Diego Co., in sand at HW level, E.L.B., July 7/59—7 males, 7 females.

Remarks. The record at Crescent City marks a northward extension of range from the previous known limit at Dillon Beach, Marin Co.

9. *Orchestoidea columbiana* Bousfield 1958

(Figure 4)

Material Examined:

Pacific Grove, Monterey Co., sand beach, D. E. Bowers, July 1/59—5 males, 10 females.

State Park, just south of Carmel Pt., Monterey Co., sand beach, D. E. Bowers, July 16/59—5 males, 5 females.

Petticoat Beach, south of Carmel, Monterey Co., sand beach, E.L.B., July 5/59—7 males, 9 females, 4 juveniles.

Remarks. The present records extend the known range southward from British Columbia to the Monterey Peninsula.

The original description (Bousfield, 1958) and key to species (Bousfield, 1957) were based on subadult specimens. In mature males (22 mm), antenna 2 is longer than the body, flagellum with more than 25 segments. In fully developed gnathopod 2, the palm of the "hand" (segment 6) has a prominent tooth near the hinge (Fig. 4g). The short powerful dactyl has a rounded prominence proximally on the inner margin which closes into the indentation above the palmar tooth. The top of the dactyl fits

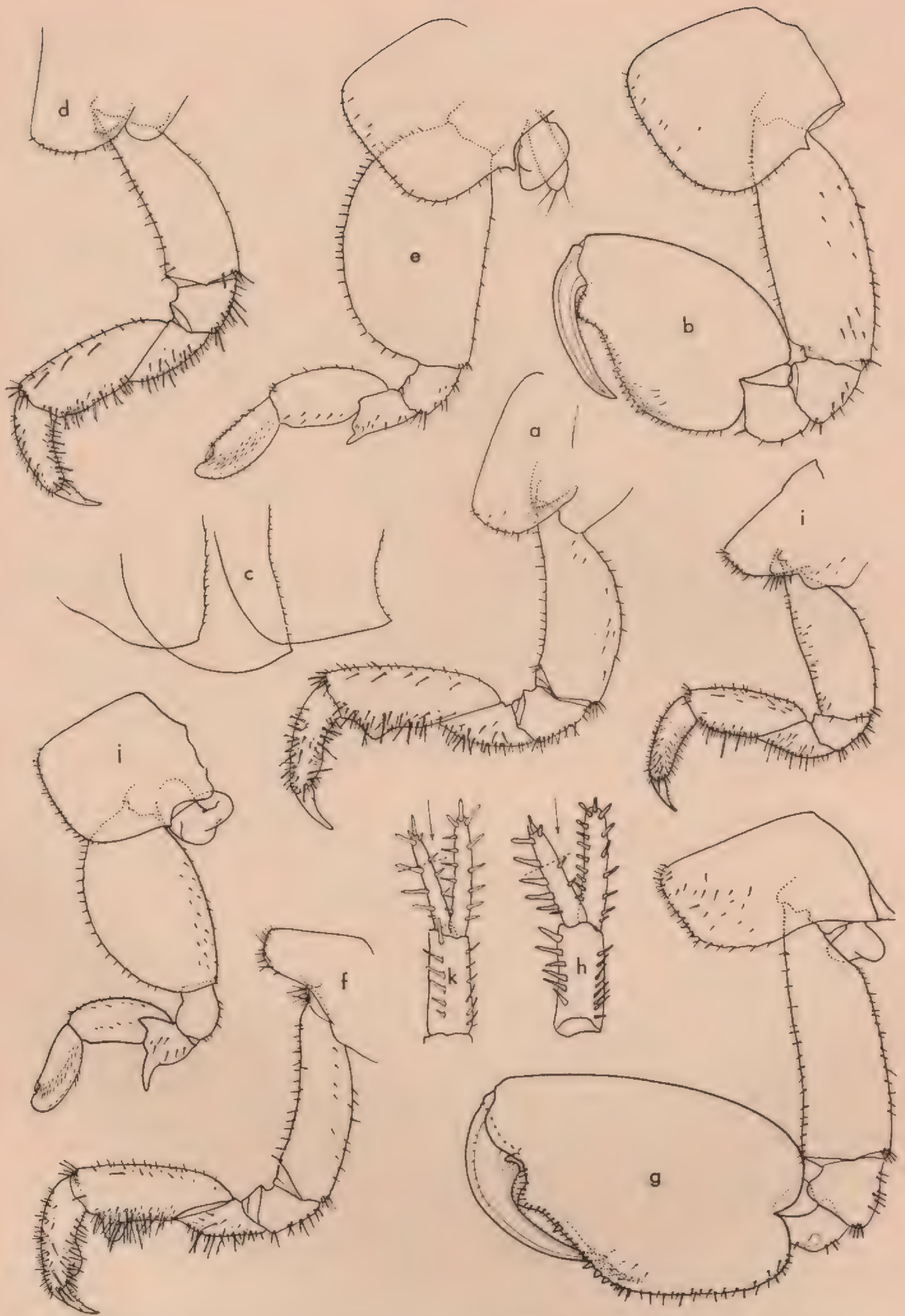


FIGURE 4. *Orchestoidea corniculata* Stout. Corona del Mar, Orange Co., male (20 mm): (a) gnathopod 1, (b) gnathopod 2, (c) abdominal side plates 1 to 3. Female (16 mm): (d) gnathopod 1, (e) gnathopod 2. *Orchestoidea columbiana* Bousfield, Petticoat Beach, Monterey Co., male (22 mm): (f) gnathopod 1, (g) gnathopod 2, (h) uropod 2. Female (18 mm): (i) gnathopod 1, (j) gnathopod 2. *Orchestoidea minor* Bousfield, Playa del Ray, Los Angeles Co., male (14 mm): (k) uropod 2.

into a groove on the inner side of the palmar angle that is lined on each side by 4 or 5 heavy spine teeth. The soft lobe on the lower margin of segment 4 persists in the largest instars. In gnathopod 1, segment 6 has a moderately prominent "blister" on the lower margin, which, however, does not form an apical "pseudopalm," as in *O. pugettensis*.

Orchestoidea columbiana is superficially like *O. californiana* but is readily recognized in the field by the dorsal pigmentation pattern of the body, irrespective of size or sex. In fully pigmented specimens of *O. californiana*, the head and all 7 thoracic and first 2 pleon segments are marked by a longitudinal dark mid-dorsal stripe which, in thoracic segments 6 and 7, and pleon segments 1 and 2, does not extend to the respective posterior borders. Pigmented areas of various shapes extend laterally and posteriorly from the mid-dorsal stripe in all but the head and thoracic segments 1 and 5. Segments 5 and 6 have faint blotches on either side, just above the coxal plates. This pattern is most strongly developed in juveniles, and all but the abdominal markings disappear in large adults.

In *O. columbiana*, however, pigments are darker, and the pattern is stronger; moreover, it persists even in fully adult animals. The mid-dorsal stripe is entirely lacking. Instead, paired dark spots occur near the posterior margins of thoracic segments 2, 3, 4, and 7 (faintly), diffuse blotching on 6, and flattened "X" pattern on abdominal segments 1 and 2. Thoracic segments 2 to 6 have fairly strong blotches on either side just above the coxal plates. Thoracic pigments tend to be a yellow ochre, those of the abdomen a dark orange.

10. *Orchestoidea minor* Bousfield 1957

(Figure 4)

Material Examined:

Playa del Ray, Los Angeles Co., fine sand at lower HW level, E.L.B., July 6/57—4 males (subadult), 4 females, 1 juvenile.

Remarks. *Orchestoidea minor* is very closely allied to *O. columbiana* but may be distinguished in the field not only by its smaller size and more slender form but by the more extensive and more diffuse dorsal pigmentation of the body. In *O. minor* the 7th (last) thoracic segment has a diffuse yellow-ochre "X" pattern near the posterior border, whereas in *O. columbiana* this segment is typically unpigmented except for two small spots posteriorly. All stages of *O. minor* may be separated from *O. columbiana* by the armature of the outer ramus of uropod 2 (Fig. 4k). In *O. minor* the spines of the inner margin extend further toward the apex than do those of the outer margin, whereas in *O. columbiana* the reverse is true.

Though this species has not been taken north of the Los Angeles area, it is known southward from localities in Baja California, Mexico.

11. *Orchestoidea californiana* (Brandt) 1851

Material Examined:

Crescent City, Del Norte Co., fine sand at HW, E.L.B., July 2/59—7 males, 6 females (2 ovig.), 8 juveniles.

Rolph, Humboldt Co., fine sand at HW, E.L.B., July 3/59—2 males, 2 females, 1 juvenile.

- Baker's Beach, San Francisco, sand at HW level, E.L.B., July 4/59—16 males, 10 females, 19 juveniles.
- Pacific Manor, 1 mile south of Mussel Rocks, San Mateo Co., D. E. Bowers, June 23/59—2 males, 2 females (ovig.).
- West end Monterey Beach, just west of Monterey peninsula Yacht Club, D. E. Bowers, June 30/59—6 males, 5 juveniles.
- Carmel, Monterey Co., sand beach, D. E. Bowers, July 16/59—2 males, 3 females (ovig.).
- Morro Strand Beach, north end, San Luis Obispo Co., fine sand, E.L.B., July 5/59—11 males, 8 females, 4 juveniles.
- Pismo Beach, San Luis Obispo Co., fine sand at wharf, E.L.B., July 10/59—12 males, 9 females, 2 juveniles.

Remarks. This species ranges from Vancouver Island, south to Laguna Beach, although it is uncommon south of Pt. Conception. The dorsal pigmentation pattern, described under *O. columbiana* (above), is perhaps the weakest (particularly in adults) of all six California species. Specimens from the white sand beach at Carmel (above) are extremely pale, almost without trace of colour pattern.

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AMPHIPOD CRUSTACEANS OF THE PACIFIC COAST OF CANADA,
I. FAMILY ATYLIDAE

BY ERIC L. MILLS

INTRODUCTION

Many collections of intertidal invertebrates were made by Dr. E. L. Bousfield of the National Museum of Canada in 1955, 1957, and 1959 on southern Vancouver Island, the Queen Charlotte Islands, northern Vancouver Island, and the mainland of British Columbia. In 1955 and 1957 the author acted as field assistant.

Collections of amphipod crustaceans from 45 stations yielded three species of the family Atylidae: *Atylus levidensus* Barnard, *A. collingi* (Gurjanova), and *A. tridens* (Alderman), none previously recorded from Canada. *A. collingi* was recorded for the first time on North American coasts.

Examination of these species led to a consideration of the fusion of the genera *Atylus* and *Nototropis*, as suggested by Barnard (1956); general support is given to Barnard's view. In addition, a key to the twenty known world species of the family was constructed, based on the limited key prepared by Gurjanova (1951).

TABLE 1
Station List (See Figure 1)

Sta. No.	Locality and Date	Habitat	Salinity	Temp.	<i>Atylus levidensus</i>	<i>Atylus collingi</i>	<i>Atylus tridens</i>
M1	Savary I., B.C. 26 Aug. 1955	Sand and boulders	25.2	14.2	—	x	—
M3	Kelly Bay, B.C. 27 Aug. 1955.....	Sand, stones	16.2	15.2	—	x	—
M11	White Rock, B.C. 30 Aug. 1955.....	Rock and sand	15.2	18.0	—	x	—
M11	W. Pt. Roberts, Wash., U.S.A. 29 Aug. 1955.....	Boulders, sand, gravel	9.1	16.4	—	x	—
F1	Whiffen Spit Sooke, V.I., B.C. 12 Aug. 1955.....	Stones, boulders, sandy gravel	31.3	10.9	x	—	—

Sta. No.	Locality and Date	Habitat	Salinity	Temp.	<i>Atylus levidensus</i>	<i>Atylus collingi</i>	<i>Atylus tridens</i>
F3	Witty's Lagoon, Victoria, B.C. 16 Aug. 1955.....	Sand flats	30.5	11.1	—	—	x
F6	Telegraph and Cadboro Bays, Victoria, B.C. 15 Aug. 1955.....	Rock, mud, sand, algae	28.5	11.7	—	—	x
F8	Friday Harbor, San Juan I., Wash., U.S.A. 21 July, 1955.....	Night light, swimming	—	—	—	—	x
F9	Sidney I. sand spit, V.I., B.C. 19 Aug. 1955.....	Sandy mud and eelgrass	29.0	15.7	—	—	x
G2	Campbell R. breakwater, V.I., B.C. 13 Aug. 1955..	Boulders, sand, and algae	24.8	12.5	—	—	x
G4	Kye Bay, Cape Lazo, V.I., B.C. 12 Aug. 1955.....	Boulders, rocks, sand	24.9	14.7	—	x	—
G14	Berkeley's stream, Departure Bay, V.I., B.C. 25 July 1955.....	Stony HW and FW stream	—	13.0	—	—	x
P4	NW end Wickaninnish Bay, V.I., B.C. 5 Aug. 1955....	Rock and sand, pools	30.2	12.5	—	—	x
P6a	SE end Wickaninnish Bay, V.I., B.C. 2 Aug. 1955....	Sandy beach, rocks	31.0	12.4	—	—	x
P6c	SE end Wickaninnish Bay, V.I., B.C. 3 Aug. 1955....	Rocks and tide pools	—	—	—	—	x
P7	Quisitis Pt., V.I., B.C. 4 Aug. 1955.....	Boulders and gravel	30.3	12.2	x	—	x
V4b	Roller Bay, V.I., B.C. 22 July, 1959.....	Coarse sand, gravel, boulders, eelgrass	32.6	10.4	x	—	x
V7	Lady Ellen Pt., V.I., B.C. 7 Aug. 1959.....	Sand, eelgrass, rocks, kelp	—	11.5	—	x	—
V17	Boat Bay, V.I., B.C. 5 Aug. 1959.....	Sand, stones, rock, eelgrass	31.1	10.2	—	x	—
V18	Kelsey Bay, V.I., B.C. 24 June, 1959.....	Sand, eelgrass, pebbles	28.9	10.5	—	x	—
V22	Oyster Bay, V.I., B.C. 21 June, 1959.....	Sand, eelgrass, pebbles	27.7	16.8	—	x	—

Sta. No.	Locality and Date	Habitat	Salinity	Temp.	<i>Atylus levidensus</i>	<i>Atylus collingi</i>	<i>Atylus tridens</i>
O1	Experiment Cove, Cape Scott, V.I., B.C. 18 July, 1959.....	Fine sand and rock, eelgrass	—	12.0	x	—	—
O3	Grant Bay, V.I., B.C. 21 July, 1959.....	Sand, shells, and rock	33.0	11.8	—	—	x
O5	Ferrer Pt. beach, V.I., B.C. 21 July, 1959.....	Sand, rock, and eelgrass	32.2	13.5	—	—	x
O11	Hesquiat, V.I., B.C. 19 Aug. 1959.....	Boulders and kelp	31.3	15.0	x	—	—
O13	Yarksis, Vargas I., B.C. 17 Aug. 1959.....	Sand beach	31.5	13.0	—	—	x
O15	Box I., Wickaninnish Bay, V.I., B.C. 16 Aug. 1959..	Rock and sand, eelgrass	31.3	15.0	x	—	—
N1	Open Bight, Rivers Inlet, B.C. 3 Aug. 1959.....	Rock and shell, sand, eelgrass	32.2	9.8	x	—	—
N6	Bremner Beach, Raynor Pt., B.C. 2 Aug. 1959.....	Fine sand, weed, eelgrass	32.4	10.0	x	—	x
H2	Parry Passage, Q.C.I., B.C. 23 Aug. 1957.....	Sand and small shells	31.5	12.4	x	—	—
H2a	Parry Passage, Q.C.I., B.C. 24 Aug. 1957	Boulders and sand	—	—	x	—	—
H8b	Delkatla Slough, Masset, Q.C.I., B.C. 25 Aug. 1957.	Mud and sand	25.5	12.7	x	—	—
H9	Delkatla Slough, Masset, Q.C.I., B.C. 27 Aug. 1957.	Boulders, eelgrass, sand	—	—	x	—	—
H11	$\frac{1}{2}$ mi. S. Old Masset, Q.C.I., B.C. 27 Aug. 1957.....	Boulders, eelgrass, sand	28.5	13.6	x	—	x
H13	Mouth of Skonun R., Graham I., Q.C.I., B.C. 4 July 1957.....	Sand and pebbles, rivermouth	—	—	x	—	—
H14	Yakan Pt., Graham I., Q.C.I., B.C. 4 July 1957..	Sand and pebbles, rivermouth	—	—	x	—	x
E1	Tlell, Graham I., Q.C.I., B.C. 6 July 1957.....	Sand and gravel	31.6	15.4	—	x	—

Sta. No.	Locality and Date	Habitat	Salinity	Temp.	<i>Atylus levidensus</i>	<i>Atylus collingi</i>	<i>Atylus tridens</i>
E17 E18	NE. corner Copper Bay, Moresby I., Q.C.I., B.C. 11 July 1957.....	Rocks and boulders	32.3	13.8	—	—	x
W1	Lepas Bay, Graham I., Q.C.I., B.C. 23 Aug. 1957.	Rocks and sand	31.5	15.9	x	—	—
W2	Inside Morgan Pt., Peril Bay, Q.C.I., B.C. 13 Aug. 1957.....	Boulders and sand	31.1	13.5	x	—	x
W4a	Nesto Pt., opp. Hippa I., Q.C.I., B.C. 12 Aug. 1957.	Rocks and boulders	32.2	14.6	x	—	x
W8	N. arm Gudal Bay, Q.C.I., B.C. 27 July 1957.....	Boulders and laminaria	29.6	11.9	x	—	x
W9	N. side Gudal Bay, Q.C.I., B.C. 26 July 1957.....	Rocks, sand, river mouth	29.3	11.2	x	—	x
W11	S. end Gudal Bay, Q.C.I., B.C. 28 July 1957.....	Boulders, sand, stream mouth	23.3	9.6	x	—	x
W12	Gudal Bay, Q.C.I., B.C. nr. mth. of S. shore stream. 29 July 1957.....	Boulders, stream mouth	—	11.5	—	—	x

Previous records of members of the family Atylidae on the Pacific coast of North America are very few. Alderman (1936), in his description of *Nototropis tridens* (now *Atylus*) from California, stated that this was the first record of a member of the Atylidae on the United States Pacific coast. There are apparently no further records until Barnard's (1956) description of *Atylus levidensus* from California and Puget Sound. The Russian workers Gurjanova (1938, 1951) and Bulycheva (1952) report closely related species found from the Japan Sea to Chukotski Peninsula. Further work on the North American Pacific coast will undoubtedly reveal presence of some of these species.

Species of the family Atylidae are primarily littoral and benthic forms. (Sars, 1892; Gurjanova, 1938, 1951), preferring high salinities and often clinging to weeds and boulders in sandy areas. Intertidal forms are generally found rather low in this zone.

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SYSTEMATIC SECTION

Family ATYLIDAE G. O. Sars

Stebbing, 1906: 327

"Body strongly compressed, carinate. Pleon segments 5 and 6 coalesced. Antenna 1, accessory flagellum rudimentary or absent. Upper lip rounded. Lower lip with inner lobes obsolescent. Mandible . . . with palp. Maxilla 1 . . . inner plate with several setae. Maxilla 2, inner plate partially fringed on inner margin. Maxillipeds, palp well developed. Gnathopods 1 and 2 subchelate, gnathopod 2 generally the more slender. Peraeopods 1-5, finger usually pointing backward. Uropod 3, rami subequal, extending beyond those of uropod 2. Telson short, deeply cleft."

Genus *Atylus* Leach

Stebbing, 1906: 328

Genus *Nototropis* A. Costa

Stebbing, 1906: 329

These genera have recently been fused by Barnard (1956). Originally both Sars (1893) and Stebbing (1906) distinguished the two genera by presence of a strong mandibular palp and lack of a dorsal notch on pleon segment 4 in *Atylus*, and presence of a slight mandibular palp and a dorsal notch on pleon segment 4 in *Nototropis*. In addition to these characteristics, the two genera, as set forth by Sars and Stebbing, differ as described below.

	<i>Atylus</i>	<i>Nototropis</i>
Antennae	rather stout	more slender
Mandible	palp large, 3rd joint spinose	palp slender, feebly spinose
Maxillipeds	outer plate not reaching end of palp 2nd joint	outer plate reaching or passing end of palp 2nd joint
Gnathopods	strongly built—both large	2nd gnathopods attenuate
Side plates	rather shallow	moderately deep
Gills	simple	pleated or pinnate
Telson	narrow	less narrow, sometimes rounded

Both Sars and Stebbing state that an accessory flagellum of antenna 1 is absent in *Nototropis*, but as the species *Atylus tridens* and *A. collingi*, both formerly members of the genus *Nototropis*, have a rudimentary accessory flagellum, this feature cannot be used to differentiate the two genera.

Atylus levidensus Barnard 1956 and *A. collingi* (Gurjanova 1951) combine characteristics of the genera *Atylus* Leach and *Nototropis* Costa. *Atylus levidensus* comes closest to *Atylus carinatus* (type species of the genus), being very similar to it in having short antennae, a broad blunt rostrum, simple gills, a narrow telson, lack of a notch on the 1st urosome segment anterior to the tooth, the small eye, pointed anterodistal end of peracopod 1 coxal plate and shape of the last segment of the maxilliped palp. However, it differs sharply in having a slender mandibular palp,

and it shares the following characteristics of the genus *Nototropis*, as shown in *Nototropis guttatus* Costa, type of the genus: long outer plate of the maxilliped, slender gnathopods (gnathopod 2 attenuated), and moderately deep side plates in the female.

Atylus collingi (Gurjanova) is intermediate between *A. levidensus* and the species originally defined as *Nototropis*. It is like *A. carinatus* in having short antennae, strong gnathopods (1 and 2 equal in size and rounded), and a strong mandibular palp. *Nototropis* features include the following: slender rostrum and rather large reniform eye, broad telson, long outer plate of the maxilliped, and moderately deep side plates in the female. Intermediate features are the partially pleated gills, rather shallow notch on urosome segment 1 anterior to the tooth, and the shape of the last segment of the maxilliped palp. Other species show intermediate features, e.g. *A. tridens* (formerly *Nototropis*) has a mandibular palp relatively as strong as that of *A. carinatus*. Variation in notching, size, and shape of urosomal teeth in instars of *A. tridens* and *A. levidensus* indicates that these characters, formerly used to distinguish the two genera, have little value as a generic distinction.

Thus, detailed examination of members of the family Atylidae, particularly *Atylus carinatus*, *A. levidensus*, *A. collingi*, and *A. tridens*, tends to support Barnard's view that the genera *Atylus* and *Nototropis* should be fused into the former genus. Examination and critical comparison of the types of the two genera and most of the species would be necessary to yield a definitive conclusion.

KEY TO KNOWN SPECIES OF THE GENUS *Atylus*

(Modified from Gurjanova, 1951)

- | | | |
|--------|---|---|
| 1 (4) | Urosome segment 1 carinate, but without pronounced notch anterior to tooth. | 2 |
| 2 (3) | Mandibular palp slender..... | <i>Atylus levidensus</i> J. Barnard, 1956* |
| 3 (2) | Mandibular palp robust..... | <i>A. carinatus</i> (Fabricius, 1793) |
| 4(13) | Dorsal side of thoracic and pleon segments without carinations or carinations not ending in teeth (<i>A. reductus</i>), notch anterior to posterior or only tooth on urosome segment 1..... | 5 |
| 5(12) | First pair of peraeopods with normal 5th and 6th joints and very short claws. | 6 |
| 6(11) | Mandibular palp normal..... | 7 |
| 7(10) | Peraeopod 3 second segment hind margin produced distally..... | 8 |
| 8 (9) | Peraeopod 4 second segment posterior margin without setae..... | <i>A. swammerdami</i> (M.-Edw., 1830) |
| 9 (8) | Peraeopod 4 second segment posterior margin with setae..... | <i>A. serratus</i> (Schellenberg, 1925) |
| 10 (7) | Peraeopod 3 second segment hind margin not produced distally..... | <i>A. minikoi</i> (Walker, 1905) |
| 11 (6) | Mandibular palp reduced to two joints..... | <i>A. reductus</i> (Barnard, 1930) |
| 12 (5) | 1st peraeopods with abnormally short 5th segment and large sickle-like claw closing on distal part of segment 4..... | <i>A. falcatus</i> (Metzger, 1871) |
| 13 (4) | Dorsal side of some thoracic and all three pleon segments carinate, or with teeth; 1st urosome segment with notch anterior to posterior or only tooth..... | 14 |
| 14(17) | Peraeopod 3 second joint with wing-like posterior lobe, margin sinuous..... | 15 |
| 15(16) | Branchiae pleated..... | <i>A. granulosa</i> (Walker, 1904) |
| 16(15) | Branchiae not pleated..... | <i>A. vedlomensis</i> (Bate and Westwood, 1862) |
| 17(14) | Second joint of peraeopod 3 without wing-like posterior lobe..... | 18 |
| 18(23) | Dorsum of urosome segments 2 and 3 (fused) smooth, without teeth or tubercles. | 19 |

* Occurs on Pacific Coast of Canada.

- 19(22) Expanded peraeopod 5 second segment with convex outline, posterodistal corner rounded. 20
- 20(21) Anterior margin of head produced into small lobe anterior to inferior antennal sinus. *A. smitti* (Goës, 1866)
- 21(20) Anterior margin of head rounding smoothly into inferior antennal sinus. Last urosomal segments (fused) sometimes with single tooth (dentate form). *A. villosus* (Bate, 1862)
- 22(19) Posterodistal corner of peraeopod 5 second segment with triangular sharp point. *A. nordlandicus* (Boeck, 1871)
- 23(18) Dorsum of urosome segments 2 and 3 (fused) with teeth or carinations. 24
- 24(25) Last urosome segments with tubercles on dorsal side. *A. guttatus* (Costa, 1851)
- 25(24) Last urosome segments without tubercles on dorsal side, but with 1 or 2 teeth. 26
- 26(31) 2 teeth on last (fused) urosome segments. 27
- 27(28) 1st urosome segment with two teeth, back tooth as large as front, 1st and 2nd coxal plates sharp anterodistally. *A. ekmani* (Gurjanova, 1938)
- 28(27) 1st urosome segment with one tooth preceded by deep notch, lower end of coxal plates 1 and 2 straight. 29
- 29(30) uropod 3 setose, extending beyond uropod 2, posterodistal lobe of peraeopod 5 second segment extending to articulation with segment 4. *A. tridens* (Alderman, 1936)*
- 30(29) Uropod 3 spinose, extending beyond uropod 2, posterodistal lobe of peraeopod 5 second segment extending only to articulation with segment 3. *A. brüggeni* (Gurjanova, 1938)
- 31(26) One tooth on last (fused) urosome segments. 32
- 32(33) 3rd uropods short, thick, not flattened or lanceolate. *A. collingi* (Gurjanova, 1938)*
- 33(32) 3rd uropods flattened, lanceolate. 34
- 34(35) Posterodistal lobe of peraeopod 5 second segment small, rounded, not produced distally. *A. homochir* (Haswell, 1885)
- 35(34) Posterodistal lobe of peraeopod 5 second segment distinct, extending to articulation of segments 3 and 4. 36
- 36(37) Telson apices rounded, with apical and lateral spinules. *A. rylovi* (Bulycheva, 1952)
- 37(36) Telson apices subtruncate, with apical spinule only. *A. atlassovi* (Gurjanova, 1951)

* Occurs on Pacific Coast of Canada.

DESCRIPTION OF CANADIAN PACIFIC SPECIES

***Atylus levidensus* Barnard (Figures 1, 4A)**

Atylus levidensus Barnard 1956, pp. 38-43, pl. 13, 14

Diagnosis:

Characterized by—

1. U2 and 3 short, spinose; U3 not lanceolate or flattened.
2. Small eye.
3. Slender mandibular palp.
4. P1 coxal plate pointed anteroventrally.
5. P3 basis expanded but without marked posterodistal lobe.
6. P5 basis with two spines and indentation posterodistally.
7. Attenuate gnathopods, 1st having five rows of spines on upper hand.
8. Carinate pleon, lacking notch in fused segments 5 and 6 and anterior to segment 4 tooth.
9. Small inner plate of 1st maxilla.

ABBREVIATIONS FOR PLATES

Ant	Antenna	Mx	Maxilla
Ep	Epimeral plate(s)	Mxpd	Maxilliped
Gn	Gnathopod	P	Peraeopod
Hd	Head	T	Telson
LL	Lower lip	U	Uropod
Md	Mandible	UL	Upper lip
		Uros	Urosome

PAnt, PGN, PT, PU—Pelagic stage.

Description of Female (12 mm, larvigerous):

Head: length nearly equal to 1st three body segments; rostrum reaching to middle of 1st peduncular segment of A1; eye very small, lightly pigmented. Antennae: antenna 1 almost equal to antenna 2; accessory flagellum very small, lobate, bearing two long setae, on inner margin of peduncular segment 3; flagellum of 15 articles. Antenna 2, flagellum subequal to peduncle, of nine articles, each bearing setae at lower distal angle and stocky spine at upper distal angle.

Mandible: palp long and slender, 2nd article bearing a single sharp seta at articulation with 3; 3rd with three long apical setae. Lower lip: inner lobes lacking. Maxilla 1: inner plate small; outer plate with 12 to 13 pectinate spines. Maxilla 2: both plates with large groups of setae on distal margin. Maxilliped: outer plate, medial margin with 11 teeth and two long subapical spines.

Gnathopod 1: segment 2 long; segment 6 palm well marked, characterized by five rows of spines, some pectinate, at angle to upper margin, distal row longest, having 23 spines (13 pectinate); palm straight, with one or two longer hooked setae and several shorter setae; coxa narrow, rounded below; attachment of both gnathopods on distal one-third of coxal plates. Gnathopod 2: quite similar to gnathopod 1, but 6th segment lacks five rows of spines and segment 5 longer than in gnathopod 1; segment 6 narrow, lower margin with three groups of hooked setae and two rows of heavy spines near lower corner of palm.

Peraeopods 1 and 2: quite similar; segment 3 very short; 7th segment pointing backward; coxa of P1 pointed at anterodistal corner, lower margin concave; P2 coxa, front margin rounded, lower margin slightly concave. Peraeopod 3: shorter than other peraeopods; segment 2 expanded, posterodistal angle with a spine; otherwise very similar to P1 and 2; segment 7 pointed outward or forward. Peraeopod 4: similar to P3, but expanded segment 2 without small posterodistal lobe and more spiny; segment 7 pointed outward or forward. Peraeopod 5: similar to P4 but aspect more spiny; segment 7 pointed forward. Gills: all unpleated, 1 to 3 somewhat club-shaped, 4th and 5th long and rounded, 6th rather small and rounded.

Uropod 1: longer than others; outer ramus subequal to inner. Uropod 2: outer ramus subequal to inner. Uropod 3: peduncle short; outer ramus subequal to inner. Telson: narrow, bearing a short blunt spine and a pair

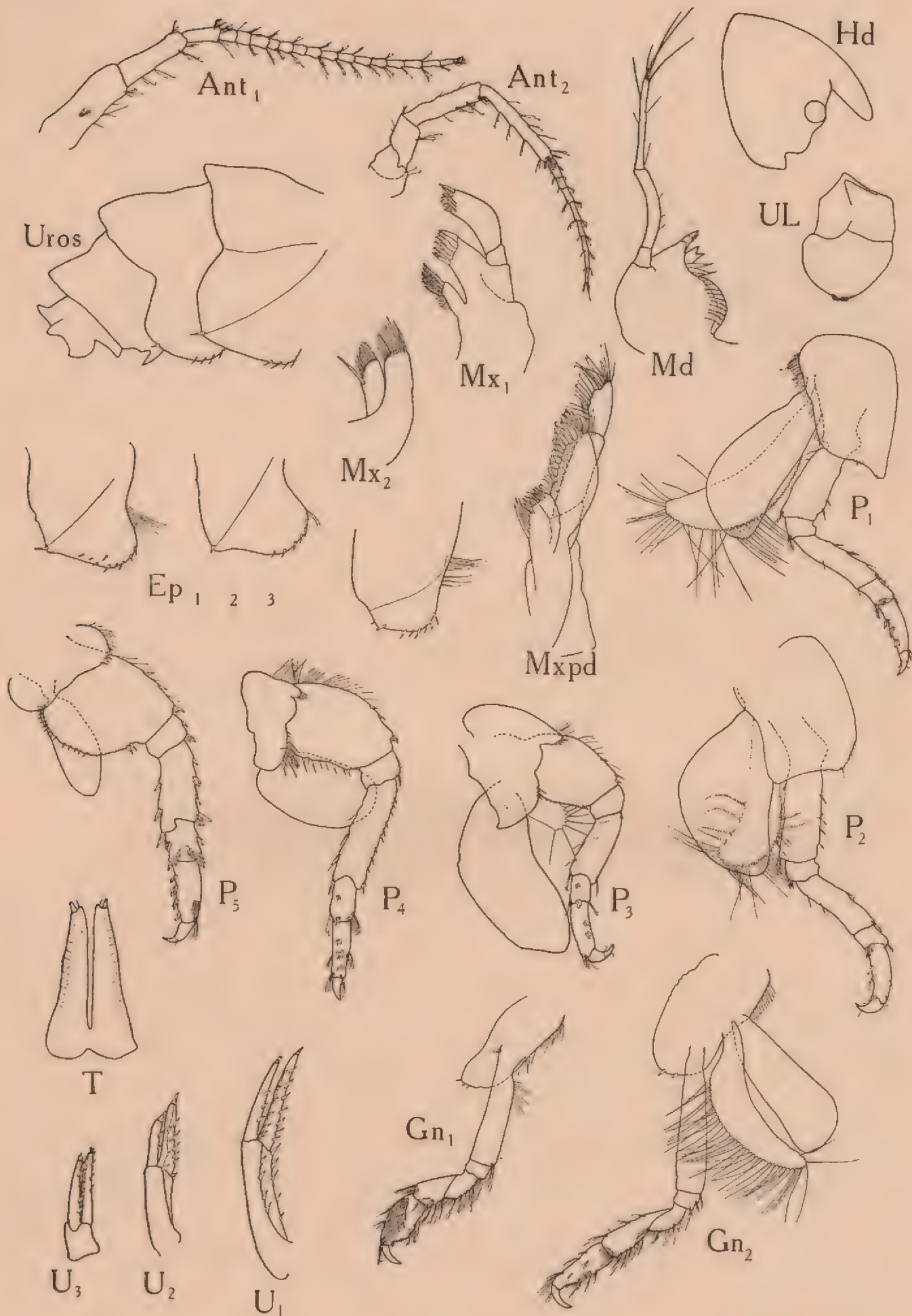


FIGURE 1.—*Atylus levidensus* Barnard. Whiffen Spit, Sooke, V.I., B.C. Female, 12 mm, larvigerous.

of curved setae in a notch at each apex. Pleopods: peduncle rather slim, somewhat setose, length three-fifths that of rami, coupling spines 2; rami subequal, of 15 articles, each bearing setae.

Pleon: segments 5 and 6 fused, projected posteriorly into a tooth which in some specimens is upturned; segments 1, 2, 3 carinate. Peraeon: all segments with a thin dorsal ridge, segments 6 and 7 slightly carinate, projecting over following segments.

Description of Male (8 mm):

Adult male not known. Subadult male (8 mm) differs from female in having coxal plates less deep, gnathopods attached at midpoint of coxal plates, antenna 1 and 2, flagella 17 and ten articles plus terminal article respectively; 5th peduncular article of antenna 2 exceeding length of 3 and 4 combined (in female, 5 subequal to 3 and 4 combined); segment 2 of both gnathopods shorter, subequal to 3, 4, 5, 6 combined; gnathopod 2 hand not so narrow; other features very similar.

Locality Records:

F1—3 ♂ ♂, 1 juv.**, NMC 3597; P7—2 subadult ♀ ♀, 5 juv. NMC 3598; V4b—2 juv., NMC 3599; O1—3 juv., NMC 3600; O11—1 subadult ♀, NMC 3601; O15—6 juv., NMC 3602; N1—1 subadult ♀, NMC 3603; N6—12 juv., NMC 3604; H2—2 subadult ♀ ♀, 5 juv., NMC 3605; H2a—7 subadult ♀ ♀, 5 juv., NMC 3606; H8b—1 juv., NMC 3607; H9—1 juv., NMC 3608; H11—2 subadult ♀ ♀, 3 juv., NMC 3609; H14—8 subadult ♀ ♀, 6 juv., NMC 3610; W1—3 subadult ♂ ♂, 14 subadult ♀ ♀, 7 juv., NMC 3611; W2—2 subadult ♀ ♀, NMC 3612; W4a—12 subadult ♀ ♀, 6 juv., NMC 3613; W8—2 subadult ♀ ♀, 26 juv., NMC 3614; W9—4 juv., NMC 3615; W11—3 subadult ♀ ♀, 14 juv., NMC 3616.

Remarks:

This species was described by Barnard (1956) on the basis of two specimens, lengths 7.5 and 6.5 mm, from Puget Sound and California respectively. While Barnard stated that the specimen described was an immature male, examination of material from the Canadian Pacific coast reveals that it is difficult, if not impossible, to differentiate immature males and females up to a length of at least 6.5 mm, and this may often be impossible even at 8 mm. Some specimens of the Canadian material show rudimentary brood plates at 6.5 mm, establishing them as females. It is suspected that some immature males may show rudimentary brood plates at this size and lose them later as the adult stage is achieved. In the Canadian material examined, the large number of specimens listed above as subadult females or juveniles may be due to these factors. An adult male has almost certainly not been examined by Barnard or myself. Features characteristic of the adult female appear to be acquired in the last few instars, including growth of the 1st and 2nd coxal plates, so that the gnathopods come to be attached on the distal two-thirds to three-quarters of the plate, where in the subadult females and males examined (<6 to 8 mm), the gnathopods were attached in the middle of the 1st two coxal plates.

**Juv. = juvenile, i.e. less than 8 mm and lacking oostegite rudiments.

The large number of subadult specimens obtained indicates that the breeding season of this species is probably spring and early summer, and that adults die after breeding or are found in a different habitat from that sampled. One of Barnard's immature specimens was taken in June, indicating that early spring is the typical time of breeding.

Atylus levidensus appears to be a fairly common member of the intertidal fauna from Puget Sound to the Queen Charlotte Islands. While Barnard (1956) considered the species rare, it is probable that this rarity arises only from its restriction to a particular ecological niche and absence elsewhere. *A. tridens* and *A. levidensus* are alike in preference for polyhaline to marine waters and sandy areas with eelgrass and rock, occurring rather low in the intertidal zone, but they differ in the requirement of a more sheltered habitat for the latter species.

***Atylus collingi* (Gurjanova) (Figures 2, 4B)**

Nototropis collingi Gurjanova 1938, p. 328, fig. 38.

Nototropis collingi Gurjanova 1951, p. 688, fig. 476.

Diagnosis:

Characterized by:

1. Upright teeth without notches anterior to them on 1st and fused 2nd and 3rd urosomal segments.
2. Stout, short 3rd uropods, margins of rami with stout spines.
3. 3rd uropods not extending beyond 2nd; telson short and inconspicuous.
4. Rather short 1st and 2nd antennae.
5. Series of short thick spines on lower margin of hand at base of palm of 1st and 2nd gnathopods—these much more developed than in *Atylus tridens* or *A. levidensus*.
6. Stout mandibular palp.
7. Spination rather than setation of paraeopods.
8. Medium-sized reniform eye.

Description of Male (13 mm):

Head: length nearly equal to 1st three body segments; rostrum rather short, pointed, reaching to middle of 1st peduncular segment of A1; eye dark, reniform; general aspect of head small, triangular. Antennae: antenna 1 only as long as peduncle of antenna 2; peduncle article 1 fringed below with fine setae (unlike female), accessory flagellum very small, bearing two setae apically; flagellum of 13 articles and a small apical article. Antenna 2 flagellum very short, of six articles and a small apical article.

Upper lip: rounded below, with a margin of fine setae. Mandible: molar well developed; palp stout. Lower lip: inner lobes small. Maxilla 1: similar to that of *Atylus levidensus* but inner plate with six plumose setae; outer plate with 11 to 12 stout spines, of which eight are pectinate. Maxilla 2: similar to that of *A. levidensus*. Maxilliped: similar to that of *A. levidensus*, but 3rd article of palp shorter and broader; outer plate medial margin with 12 to 15 teeth.

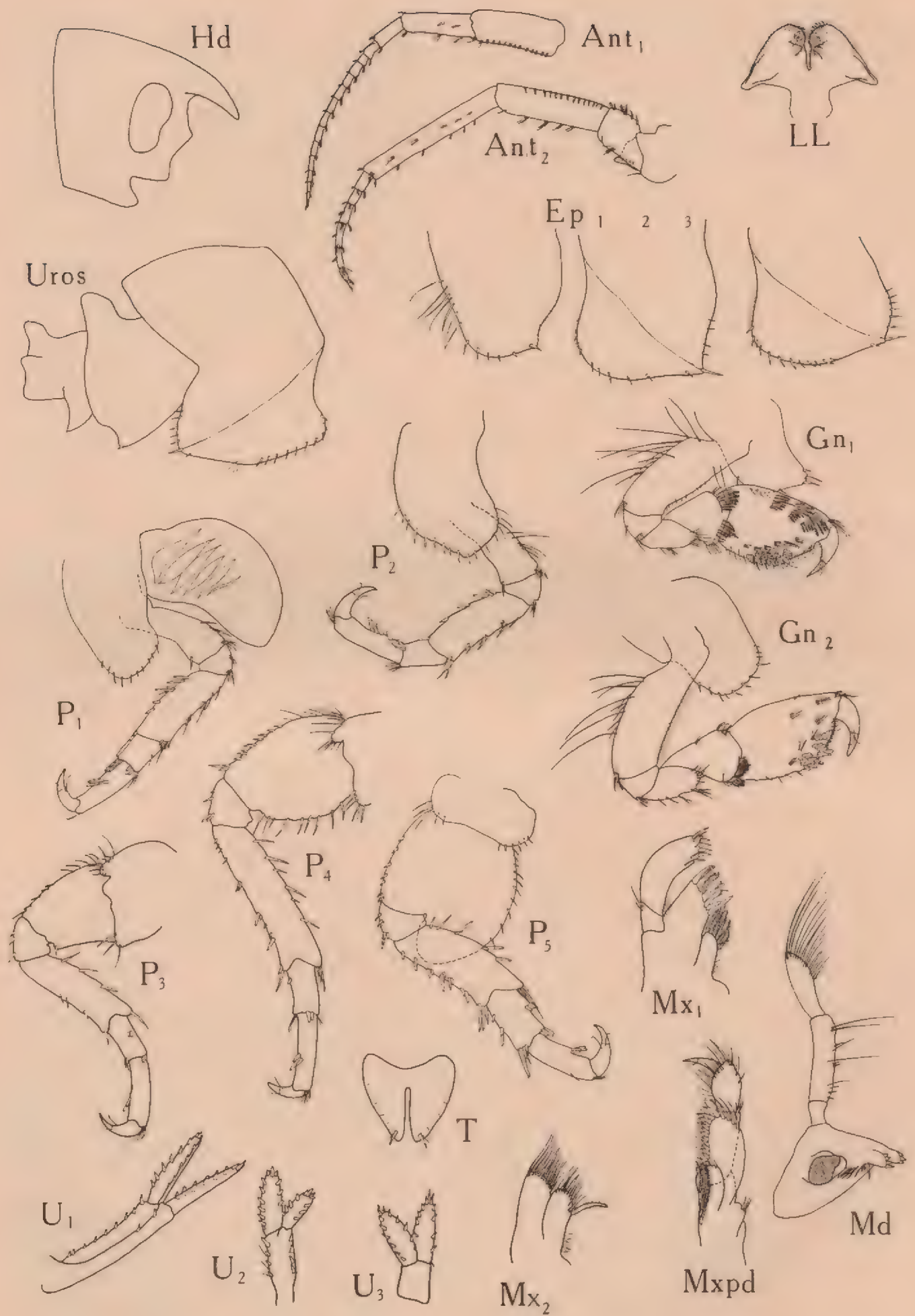


FIGURE 2.—*Atylus collingi* (Gurjanova). Oyster Bay, V.I., B.C. Male, 13 mm.

Gnathopod 1: short and stout; segment 2 short; segment 6 well developed, with several groups of stout peg-like spines on lower margin; hand with three rows of spines, some pectinate, at angle to upper margin; palm heavily set with many short and a few long sensory setae; coxa slightly expanded distally, projecting forward anterodistally. Gnathopod 2: proportions as in gnathopod 1; lacking three rows of pectinate spines characteristic of gnathopod 1; coxa narrow.

Peracopods 1 and 2: quite similar; all segments bearing groups of peg-like spines and few setae; dactyl pointed outward and backward; P2 coxa projected backward in a broad lobe. Peracopod 3: segment 2 flattened; spination of other segments similar to that of P1 and P2; dactyl pointed forward and inward. Peracopod 4: longer than other peracopods; segment 2 expanded; coxa similar to P3; dactyl pointed forward and inward. Peracopod 5: short and stocky; dactyl pointed forward and inward. Gills: 1st three gills partially pleated, lobate, 4th, 5th, and 6th small, quadrate, unpleated.

Uropod 1: longer than U2 and 3 and extending beyond them; rami slightly subequal. Uropod 2: rami slightly flattened, subequal. Uropod 3: rami similar to those of U2. Telson: short, broad, inconspicuous, a few short setae along the margins. Pleopods: peduncle about two-thirds length of rami, stout; coupling spines 2; rami slender, setose, with about 17 articles.

Pleon: segments 5 and 6 fused, bearing a dorsal upturned tooth; segment 4 bearing a similar tooth; neither tooth with a deep groove anteriorly; segments 1, 2, 3 carinate, dorsally ridged. Peraeon: all segments with a thin dorsal ridge, carination beginning on segment 6, teeth projecting over following segments; body rather thin, but not so thin as that of *A. levidensus*.

Description of Female (10 mm):

General aspect similar to male, but antennae shorter and coxal plates deeper; 1st antenna, 1st peduncular segment without fine fringe of setae below, flagellum of nine articles and a small apical article; second antenna, article 4 lacking row of fine clumped setae on inner dorsal margin, flagellum of six articles and a small apical article; gnathopods attached on distal third of coxal plates, unlike male where attachment is in middle of plate; gnathopod 1, slightly narrower than that of male, smaller, three characteristic rows of spines reduced, stout peg-like spines at base of palm longer and fewer, segment 2 posterior margin more densely setose, gnathopod 2, segment 6 much more narrow, setation similar to male, peg-like spines on lower margin of hand longer and fewer; oostegites narrow, rather small, the convex margin with many long setae; other features similar to male.

Locality Records:

M1—1 ♀, 6 juv., NMC 3617; MC—1 juv., NMC 3618; M11—1 imm. ♀, 1 juv., NMC 3619; M11—7 juv., NMC 3620; G4—1 juv., NMC 3621; V7—1 ♀, 4 ♂ ♂, 6 juv., NMC 3622; V17—5 ♀ ♀, 5 juv., NMC 3623; V18—1 ♂, 1 ♀, 1 juv., NMC 3624; V22—21 ♂ ♂, 14 ♀ ♀, 57 juv., NMC 3625 and 3626; E1—3 ♀ ♀, 7 juv., NMC 3627.

Remarks:

The list above constitutes the first records of this species from the Pacific coast of North America. Gurjanova (1938) describes the species from the Sea of Japan. *Atylus collingi* appears to be euryhaline and is found in waters of higher temperatures than are the other two species. It resembles them in requiring a sand habitat with or without eelgrass and is found in more sheltered areas than *A. tridens* or its close relative *A. levidensus*, typically in sheltered inside waters, such as the Sea of Japan and the Strait of Georgia. This species was never found with the other species previously considered, indicating that its habitat preferences are considerably different from those of *A. tridens* and *A. levidensus*.

***Atylus tridens* (Alderman) (Figures 3, 4C)**

Nototropis tridens Alderman 1936, pp. 58-59, fig. 20-25.

Diagnosis:

Characterized by:

1. Large reniform eye.
2. Stout mandibular palp, last article setose.
3. Robust gnathopods.
4. 3rd uropods flattened and lanceolate, margins with long setae.
5. Inner plate of maxilla 1 with 5 to 8 plumose setae.
6. Pleon segments 5 and 6 united, each with a small tooth; a deep indentation anterior to large tooth on segment 4.
7. Differs from *Atylus brüggeni* (Gurjanova) in having setose, not spinose rami of uropod 3, deeper inferior antennal sinus, greater length of posterodistal lobe of segment 2 of peraeopod 5, rounder anterodistal corner of peraeopod 1 coxal plate, shorter rostrum, different shape of urosomal teeth, sharp hind lower corner of epimeral plate 3, uropod 3 extending beyond uropod 2.
8. P3, 2nd segment produced posterodistally into lobe bearing spine.

*Non-pelagic Stage**Description of Male (12 mm.):*

Head: with rostrum about as long as 1st three body segments; rostrum reaching to middle of antenna 1, 1st peduncular segment; eye large, reniform, dark reddish brown to purple in preserved specimens, larger in mature males than females. Antennae: 1st antenna slightly subequal to 2nd; accessory flagellum minute on inside of 3rd peduncular segment bearing two setae; flagellum with 16 to 18 articles in mature males, fewer in previous instars. Antenna 2, flagellum with 22 articles; peduncular article 3 with a rounded medial lobe projecting forward; article 4 with an angular dorsal surface on which is a row of clumped setae.

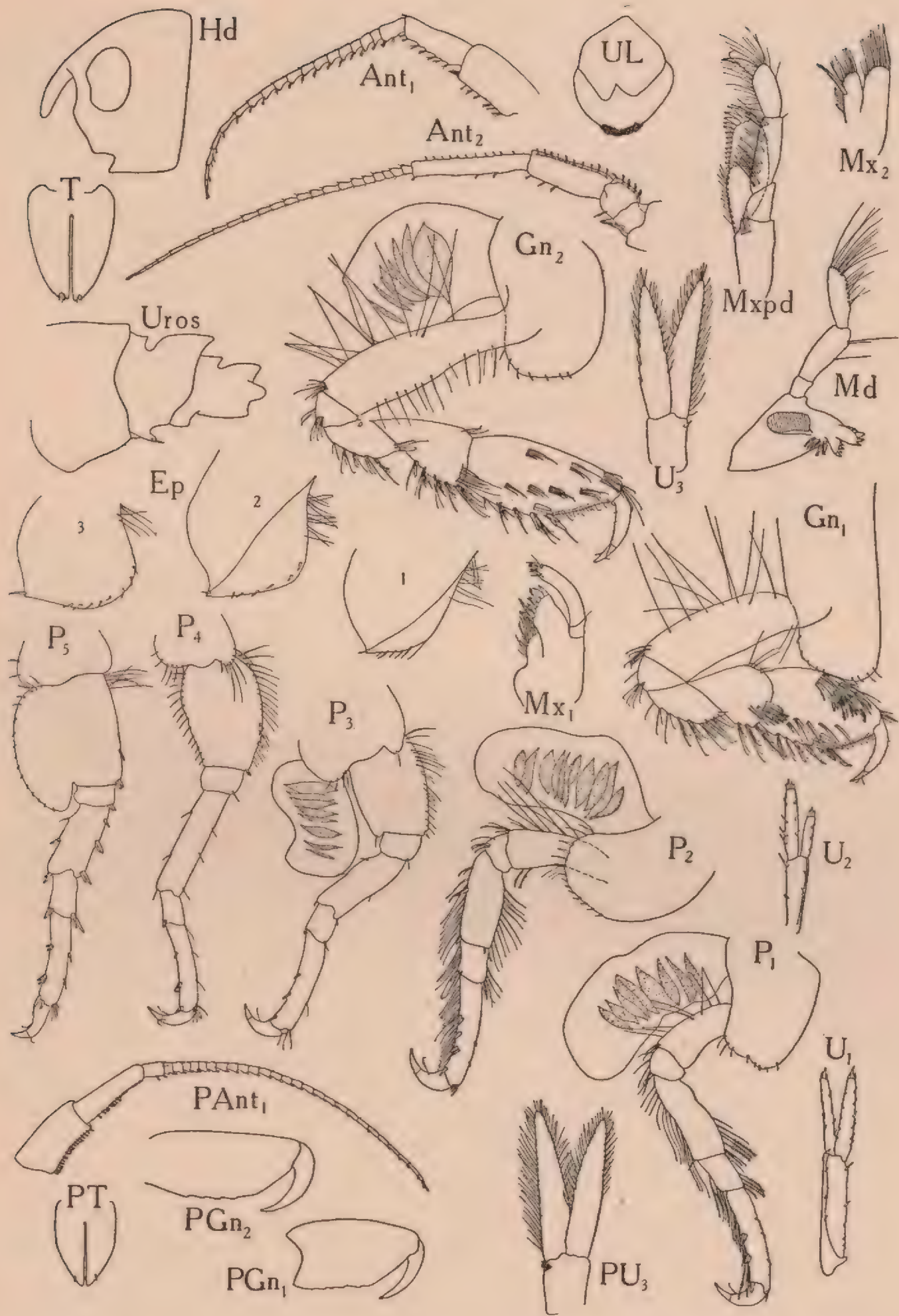


FIGURE 3.—*Atylus tridens* (Alderman). Non-pelagic—S.E. end Wickaninnish Bay, V.I., B.C. Male, 12 mm. Pelagic—Friday Harbor, San Juan I., Wash. Male, 20 mm.

Mandible: several plumose setae in spine row; palp stout, 3rd article margin oblique with about 25 long setae. Lower lip: without inner plates; outer plate medial margin with fine setae; mandibular processes twisted. Maxilla 1: outer plate with 10 to 11 pectinate spines and one or two smooth spines. Maxilliped: inner plate about half as long as outer and tipped with three stout spines; outer plate with 10 to 16 stout spine-like teeth and two heavy setae.

Gnathopod 1: triangular segment 5 with three short rows of pectinate setae along articulation with segment 6; segment 6 with four short rows of 8 to 10 spines each, some pectinate, perpendicular to upper margin, 1st (proximal) row rudimentary or absent in earlier instars than adult. Coxa quadrate, lower corners rounded. Gnathopod 2: segment 6 relatively longer than in gnathopod 1; four groups of pectinate spines lacking from hand; other features similar to gnathopod 1. Coxa quadrate, rounded below.

Peraeopods 1 and 2: very similar; dactyl pointed posteriorly; long setae on distal segments; P1 coxa quadrate; P2 coxa rounded. Peraeopod 3: shorter than P1 or P2; without long setae; dactyl pointed outward or posteriorly; segment 2 expanded, posterodistal projection small, with a spine; otherwise similar to P1 and P2. Peraeopod 4: dactyl pointing outward or backward; segment 2 expanded; posterior margin not produced into distal lobe; segment 4 somewhat longer than in other peraeopods; otherwise similar to P3. Peraeopod 5: segment 2 expanded and produced posterodistally into rounded lobe; other segments similar to P3, but more spiny, spines replacing setae on anterior margins of segments; coxa shallow, somewhat triangular. Gills: 1st four pleated, last two unpleated; pleated gills with about 15 pleats, but in some individuals 1st gill has no pleats; gills 1 to 3 long and large; 4 and 5 quadrate and small.

Uropod 1: extending beyond tip of U3. Uropod 2: shorter than other uropods. Uropod 3: some setae of rami with short spines at base; tips of both rami rather square and bearing three apical setae. Telson: longer than wide; small notch at each apex bearing a small spine and seta. Pleopods: peduncles rather muscular, about one-half the length of rami; coupling spine finger-like, down-curved; rami with 25 to 28 articles; peduncle of pleopod 2 most muscular.

Pleon: segments 5 and 6 fused, each bearing a small tooth; segment 4 with a large tooth, in front of which is a deep indentation; segments 1, 2, 3 carinate. Peraeon: last two segments carinate dorsally; carination is a variable characteristic, apparently more pronounced in later instars than earlier ones; the pelagic form shows the greatest degree of carination, though in one collection (H14) carination varies directly with increasing size of individuals from that typical of the non-pelagic stage to that of the pelagic stage.

Description of Female (13 mm.):

Antennae: shorter than in male; antenna 1 peduncular segments with fewer groups of setae, flagellum of 14 to 17 articles; antenna 2 setae fewer and longer; article 4 of peduncle without angular dorsal surface, but bearing a row of clumped setae. Mouthparts: similar to male. Gnathopod 1: segment 6 smaller than in male; segment 2 attached near end of coxal plate; in male, attachment is near middle of plate; coxal plate deeper than in male; only three rows of pectinate spines perpendicular to upper

margin of segment 6. Gnathopod 2: segment 6 smaller and shorter than in male and palm less well marked; other features much as in male; oostegites long, curved, with many long setae on convex margin. Peraeopods: P1 and P2 less setose than in male, otherwise similar except for presence of oostegites on P1-3. Uropod 3: inner margin of outer ramus with fewer long setae than in male, outer margin with only a few spines near the apex; inner ramus with sparse setae on medial margin, outer margin with only a few spines; tip of rami square as in male and with similar spines. Other characteristics similar to those of the male.

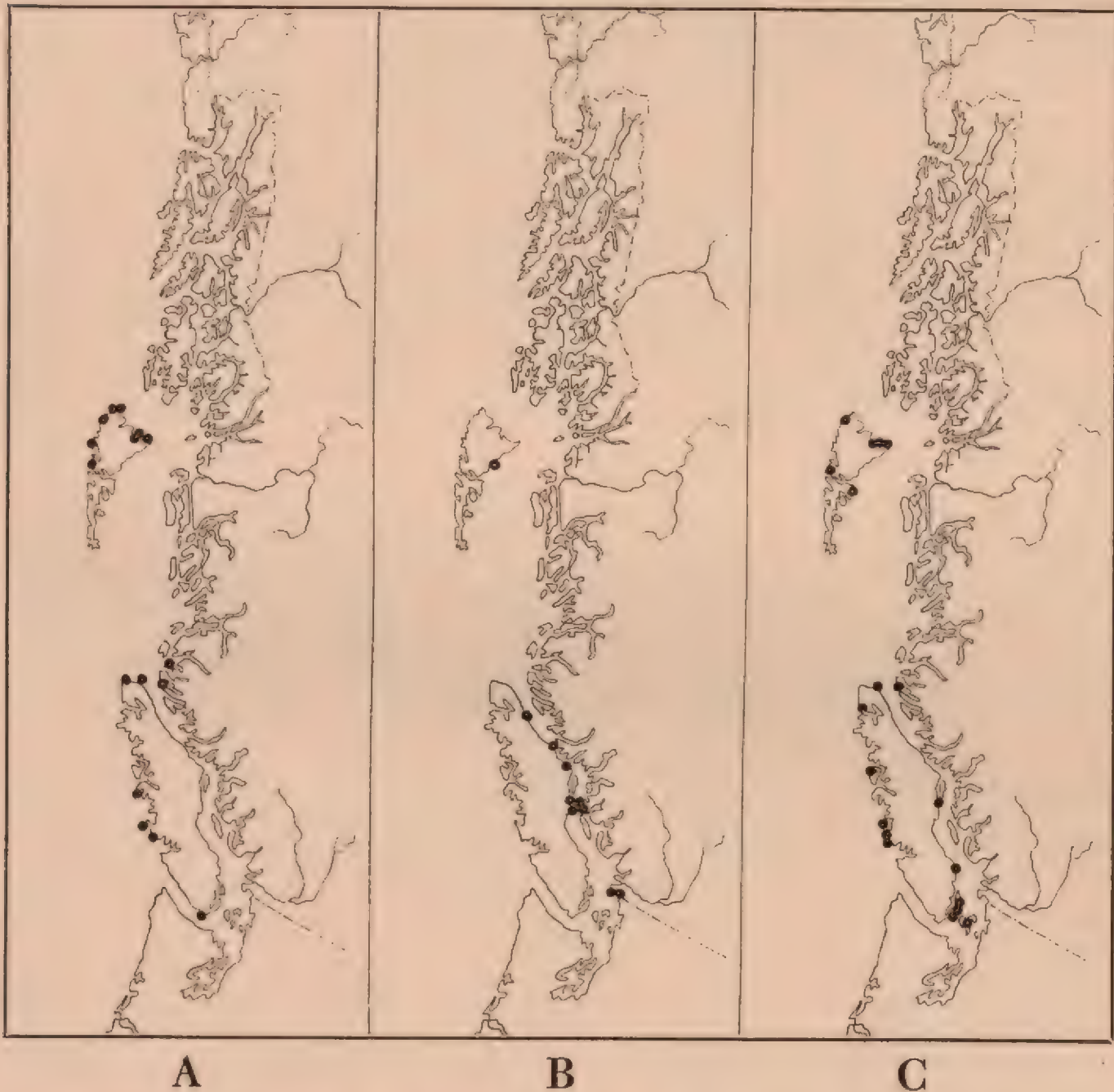


FIGURE 4. Occurrences: (A) *Atylus levidensus*, (B) *A. collingi*, (C) *A. tridens*.

Pelagic Stage

Description of Male (20 mm.):

Head: as in non-pelagic stage. Antennae: proportions of articles as in non-pelagic stage; antenna 1, lower margin of peduncular article 1 with several groups of short, fine setae forming a fringe along the length

of the article; article 2 with similar fringing setae; flagellum of 28 articles; antenna 2, flagellum of 32 articles; otherwise similar to non-pelagic stage.

Mandible: as in non-pelagic stage, but 3rd palp article with about 40 long setae. Maxilla 1: inner plate with eight plumose setae—number of setae here apparently varies from five to eight with increasing size of animal; palp with eight fairly short spines and one long spine, also setae at end of 2nd joint.

Gnathopod 1: 2nd segment considerably longer than 6th; segment 6 longer and more quadrate than in non-pelagic stage, palm well marked, with a thick group of hooked setae; tuft of setae at base of dactyl better developed than in non-pelagic stage. Gnathopod 2: segment 2 considerably longer than 6th; segment 6 more elongate than in gnathopod 1.

Peraeopods 1 and 2: more heavily setose than in non-pelagic stage; in general, spines and setae better developed.

Uropod 3: rami slightly subequal, flattened, lanceolate; setae longer and more fine than in non-pelagic stage, some with spines at bases; tips of both rami rounded, not squared. Telson: as in non-pelagic stage, but with only a very slight indentation near each apex with a fine small seta. Pleopods: pleopod peduncles relatively more muscular than in non-pelagic stage, peduncle subequal to rami, rami with about 31 articles.

Peraeon: coxal plates somewhat deeper in adults of pelagic stage than in those of non-pelagic stage.

Description of Female (20 mm):

Quite similar to male, but coxal plates deeper; antenna 1, first and 2nd peduncular articles without lower fringe of fine setae, having a few groups of longer setae; antenna 2, setae fewer and longer, no angular setose dorsal strip on peduncle article 4; uropod 3, short spines replacing long setae of male; telson quite similar, but apex more pointed; gnathopods similar except segment 6 of both attenuated in female; antenna 1, flagellum articles 23; antenna 2, flagellum articles 25.

TABLE 2
Summary of Differences Between Stages

	Non-pelagic Stage	Pelagic Stage
1. Breeding length.....	12 mm	20 mm
2. Mx 1 palp teeth.....	5-6	8
inner plate setae.....	5-6	8
3. Mandibular palp setae...	c. 25	c. 40
4. Gnathopods.....	ovoid	more rectangular
5. Mxpd outer plate teeth...	10-16	16
6. Peraeopods and epimeral plates.....	sparingly setose	heavily setose
7. Peraeon and pleon.....	moderate carination	strong carination
8. Telson.....	apices notched, with spines	apices almost entire, with small setae
9. Uropod 3.....	square-tipped; setae short	round-tipped, setae long
10. Male ant. 1.....	peduncular articles 1 and 2 without fine fringe of setae on ventral margin	peduncular articles 1 and 2 with fine fringe of setae on ventral margin

Locality Records:

F3—n. pel. 1 ♂, 1 ♀, 9 juv., NMC 3628; F6—pel. 2 ♀ ♀, n. pel. 2 ♀ ♀, 8 juv., NMC 3629, 3632; F8—pel. 8 ♂ ♂, 1 ♀, NMC 3630, 3631; F9—n. pel. 2 juv.; G2—n. pel. 1 juv., NMC 3633; G14—n. pel. 1 juv., NMC 3834; P4—n. pel. 4 juv., NMC 3634; P6a—n. pel. 4 ♂ ♂, 9 ♀ ♀, 73 juv., NMC 3635; P6c—n. pel. 3 ♀ ♀, 11 juv., NMC 3636; P7—n. pel. 1 juv., NMC 3637; V4b—n. pel. 3 ♂ ♂, 3 ♀ ♀, 5 juv., NMC 3638; O3—n. pel. 4 juv., NMC 3639; O5—n. pel. 2 ♂ ♂, 1 ♀, 3 juv., NMC 3640; O13—n. pel. 2 ♂ ♂, 1 ♀, 6 juv., NMC 3641; N6—n. pel. 1 ♂, NMC 3642; H11—n. pel. 1 juv., NMC 3643; H13—n. pel. 1 juv., NMC 3644; H14—pel. 5 ♂ ♂, 19 juv., NMC 3645; E¹⁷/₁₈—n. pel. 1 ♂, NMC 3646; W2—n. pel. 1 ♂, NMC 3647; W8—n. pel. 4 juv., NMC 3648; W9—n. pel. 8 juv., NMC 3649; W11—n. pel. 1 juv., NMC 3650; W12—n. pel. 1 juv., NMC 3651.

Remarks:

Atylus tridens (Alderman) 1936 was described from specimens taken at a night light near Moss Beach, San Mateo County, California. The collections outlined in the present paper extend the range of this species to include Vancouver Island and the Queen Charlotte Islands, British Columbia.

The British Columbia specimens differ from the original description in a few details, but these may be due to use of earlier instars and lack of detail in the original description. Alderman states that *A. tridens* has 16 segments in the flagellum of the first antenna and 19 segments in 2nd antennal flagellum, while British Columbia specimens show 16 to 28 and 23 to 31 respectively. However, variability in the present material is sufficient to make these differences appear unimportant. Alderman describes the inner plate of the first maxilla as bearing four plumose spines; in the present material, the number of inner plate spines varies from five to eight, generally larger in number in the later instars. In most other details agreement is close, but northern material shows a slightly greater degree of setation.

Atylus tridens is found to occur in two stages, (1) a non-pelagic stage, reaching breeding condition at about 12 mm, and (2) a pelagic stage, reaching breeding condition at 20 mm. Differences of degree are found between the two stages, and intermediate conditions of most characters are found in several collections. The primary difference between the two stages lies in the size at which breeding occurs. In addition, the pelagic stage is characterized by a greater number of plumose setae on the inner plate of the first maxilla, greater number of apical setae on the mandibular palp, slightly different shape of gnathopods, greater number of teeth on the medial margin of the maxilliped outer plate, and a slightly greater degree of setation and spination of the peraeopods and epimeral plates, as well as a greater degree of carination of peraeon and pleon. The telson of the non-pelagic stage shows a notch on each half near the apex with a terminal spine, whereas the other stage has only a rudimentary notch with a fine seta. In the non-pelagic stage, the 3rd uropods are square-tipped, bearing shorter setae on the margins; in the other stage the 3rd uropods are rounded at the tip, bearing longer and finer setae. Adult males in the final instar of the pelagic stage show a characteristic fine fringe of setae along the lower margins of articles 1 and 2 of the first antenna. In earlier instars,

intermediate conditions between the typical female and immature state with groups of longer clumped setae have been found, indicating that the adult male condition is achieved in a series of steps during successive instars. The non-pelagic stage shows a somewhat similar characteristic, but in most males examined the fringing setae are more clumped than in the adult male of the pelagic stage. It is possible that all males of the non-pelagic stage in the collections were slightly subadult. The most characteristic collection of the pelagic stage (from F8) was taken at a night light. One other collection (H14) shows a complete variation from characters typical of the non-pelagic stage in smaller animals to those typical of the pelagic stage in larger animals. Because of these factors, it seems advisable to consider these forms as stages of the single species *Atylus tridens* (Alderman).

In three fully marine localities (N6, E17, and F3), otherwise characteristic non-pelagic forms show an increase in setation, an increased degree of carination, and a more pointed tooth on pleon segment 5. Within these collections, however, considerable variation occurs. It is possible that salinity may have some effect on the expression of these characters.

In both stages, gnathopods of the male are attached near the middle of the coxal plates, while in females the attachment is near the distal end of the coxal plates. In males, gnathopod 1 is attached at a point about one-half the distance from the lower margin; gnathopod 2, also about one-half the distance from the lower margin. In females the point of attachment is one-third the distance from lower margin for gnathopod 1 and one-quarter for gnathopod 2. Earlier instars of both sexes show the same ratio as in the adult male.

From ecological data with the collections, *Atylus tridens* appears to be a polyhaline to marine animal, present in outer coast situations and sheltered high salinity areas, where some sand with eelgrass and rock is present. As mentioned previously, there appear to be some modifications in body aspect and setation where salinity is fully marine.

A. tridens shows affinities with *A. brüggeni* (Gurjanova), *A. atlassovi* (Gurjanova), and *A. rylovi* (Bulycheva). It may be distinguished from *A. brüggeni* by the presence of setose lanceolate rami of the 3rd uropods, uropod 3 extending beyond uropod 2, a deeper inferior antennal sinus, longer posterodistal lobe of peraeopod 5 segment 2, rounded anterodistal corner of peraeopod 1 coxal plate, shorter rostrum, backward- rather than upward-projecting urosomal teeth, and the sharp lower hind corner of epimeral plate 3.

A. tridens differs from *A. atlassovi* in shape and length of the rostrum and structure of the urosomal teeth, but from Gurjanova's figures they appear to be very similar in the structure of the gnathopods, third uropods, and peraeopod 3 and 5 second segments. Examination of material is probably necessary to adequately define differences between the two species.

A. rylovi may be distinguished by the presence of only one tooth on the fused urosomal segments, shorter rounded telson, bearing two small spines near each apex, the more lobate peraeopod 3 coxa, sparse setation of maxilla 1 inner plate, blunt spineless posterodistal angle of epimeral plate 3, and anterodistal projection of peraeopod 4 second segment. Similarities appear in antennae, gnathopod shape (like pelagic stage of *A. tridens*, flattened, lanceolate third uropods, posterodistal lobe of peraeopod 5 second segment and the shape of peraeon side plates 2 and 7.

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FISH REMAINS FROM A 600-YEAR-OLD ST. LAWRENCE RIVER IROQUOIS SITE

By D. E. McALLISTER

INTRODUCTION

Fish remains were discovered by archaeologists of the National Museum of Canada while salvaging materials from the site of a prehistoric Iroquois village. Because of the age of the remains and hence their pertinence to postglacial dispersal, it was thought of interest to report on the fishes.

The site was located on a farm 4 miles northwest of Prescott, Grenville County, Ontario, about 6 miles from the St. Lawrence River. The specimens were 6 to 7 inches below the surface in sandy soil around old house floors and in storage pits. The bones were stained a dark brown. Along with the fishes were remains of beaver, deer, about a dozen humans, as well as various artifacts.

The site is ascribable to a Roebuck type culture ancestral to the Onondaga-Oneida nations of the Iroquois. Dating by means of pottery studies (MacNeish, 1952) tentatively places the village at A.D. 1350 $\pm$ 100 years (i.e. about 610 years ago). Wintemberg (1936) presents a general report on a prehistoric village site close to Roebuck, Grenville County, about 8 miles northwest of our site. Wintemberg (1936) mentions several fishes, included in this account, which were identified by E. A. Reid of the United States National Museum.

Present-day distributions are from Hubbs and Lagler (1958). The measurement given for each bone is its greatest length.

ACKNOWLEDGMENTS

The author is grateful to Dr. R. S. MacNeish for supplying information about the site and its age; to J. A. Dellaire for sorting out the fish bones and drawing his attention to them; and to Dr. W. B. Scott and Dr. E. J. Crossman, of the Royal Ontario Museum, for the use of their skeletal collection; and to J. A. Crosby for making the drawings.

ACCOUNT OF THE FISHES

LEPISOSTEIDAE

Lepisosteus osseus (Linnaeus)—longnose gar

Referred Material: none

Wintemberg (1936) reported remains of the "gar pike" at the village site near Roebuck. The longnose gar is presently found from Florida and northern Mexico northward through the Mississippi drainage; in all the Great Lakes but Superior, and down the St. Lawrence-Champlain drainage to its mouth.

ESOCIDAE

Esox lucius Linnaeus—northern pike

Referred Material: NMC 59-413-S, left dentary 63 mm long; NMC 59-416-S, left preopercle, 32 mm, with upper tip missing. Wintemberg (1936) also reported pike from the site near Roebuck.

The dentary and the preopercle can be identified on the basis of size and the pattern of preoperculo-mandibular pore openings.

The northern pike is presently distributed from northern Alaska and British Columbia southeastward to the northern Mississippi system, throughout the Great Lakes drainage; southern and eastern Hudson Bay drainage; eastern New York and north of northern New England on the Atlantic coast to Nova Scotia, New Brunswick, most of Quebec, and in Labrador.

Esox sp.—a pike species

Referred Material: NMC 59-414-S, right dentary with three teeth, 60 mm, with posterior tip missing (Figure 1a); NMC 59-415-S, right dentary, 64 mm; NMC 59-417-S, right preopercle, 30 mm, central portion; NMC 59-418-S, right cleithra, 45 mm, upper third missing; NMC 59-419-S, right cleithra, 58 mm; NMC 59-420-S, right quadrate, 15 mm; NMC 59-421-S, right palatine, 40 mm, posterior tip missing (Figure 1b); NMC 59-422-S,

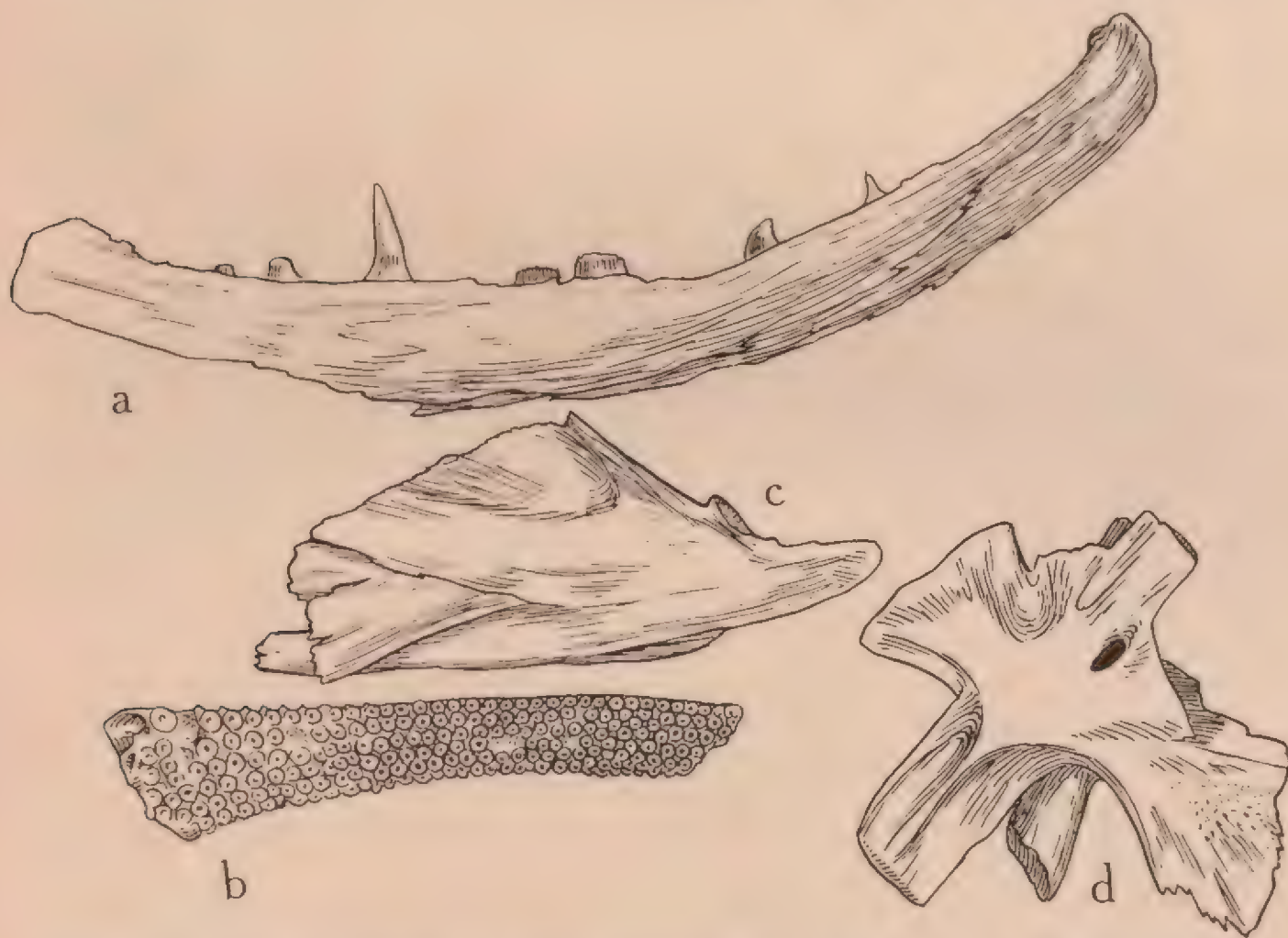


Figure 1. a—External surface of right dentary bone of *Esox* sp.; b—Ventral surface of right palatine bone of *Esox* sp.; c—External surface of left articular bone of *Esox* sp.; d—External surface of right hyomandibular of *Esox* sp.

right hyomandibular, 26 mm (Figure 1d); NMC 59-423-S, left cleithra, 49 mm, lower arm missing; NMC 59-424-S, left articular including piece of a dentary between its fork, 30 mm (Figure 1c); NMC 59-425-S, right cleithra, 57 mm.

Most of the above bones may be excluded from *Esox americanus* on the basis of size. The present state of our osteological knowledge does not enable us to determine whether they belong to *Esox masquinongy* or *Esox lucius*, though they probably belong to the latter.

CATOSTOMIDAE

Subfamily ICTIOBINAE

Ictiobus bubalus ? (Rafinesque)—smallmouth buffalo

Referred Material: none

Wintenberg (1936) reported "buffalo fish," possibly *Ictiobus bubalus*, from the site near Roebuck. The only buffalo fish definitely now known to occur in Canada is *Megastomatobus* (= *Ictiobus*) *cyprinella* (Valenciennes) which is found in Lake Erie at Long Point Bay (Scott, 1957) and generally from Saskatchewan and Red River drainages of Canada south through the central Mississippi system to Texas, Alabama, and Louisiana. *Ictiobus bubalus* has a similar distribution but is found in the Great Lakes drainage only in southern Michigan. *Ictiobus niger* is reported from eastern Nebraska and Minnesota to Lake Michigan and (one report) Lake Erie south through the central Mississippi system to the Gulf Coast and Mexico. From the present distribution it would seem more likely that the species was *cyprinella*.

Carpiodes sp.—carpsucker

Referred Material: none

Reported by Wintenberg (1936) as "carp," *Carpiodes* sp. Probably referable to *Carpiodes cyprinus* (LeSueur), since none of the other species of this genus now extend further north than southern drainages of the Great Lakes (and even these records are uncertain). *Carpiodes cyprinus* is known at present from the northern Mississippi system, all the Great Lakes (except Superior), and the St. Lawrence River system; south in the Atlantic drainage from the Susquehanna to the Roanoke; and west to southern Alberta.

Subfamily CATOSTOMINAE

Catostomus commersonii (Lacépède)—white sucker

Referred material: NMC 59-427-S, right pharyngeal arch, 19 mm, half missing (Figure 2a).

Occurs at present in Mackenzie River, Hudson Bay, and Quebec-Labrador peninsula drainages, south in Atlantic and Mississippi drainages to Georgia, Arkansas, and Oklahoma; including the whole Great Lakes drainage and northern British Columbia.

Catostomus catostomus (Forster)—longnose sucker

Referred material: NMC 59-426-S, right pharyngeal arch, 21 mm (Figure 2b).

Occurs at present from Arctic and Bering Sea drainages of British Columbia and northern Washington, south and east to southern Hudson Bay, the Great Lakes, Quebec-Labrador peninsula, New Brunswick, Nova Scotia, and northern New England.

Catostomidae (undetermined genus and species)

Referred Material: NMC 59-528-S, left hyomandibular, 38 mm; NMC 59-429-S, left preopercle, 30 mm.

PERCIDAE

Perca flavescens (Mitchill)—yellow perch

Referred Material: NMC 59-430-S, left preopercle, 20 mm (Fig. 2c); NMC 59-431-S, right preopercle, 25 mm, in two fragments.

The yellow perch is presently found from Lesser Slave Lake and southern Hudson Bay drainages, throughout the Great Lakes system to Nova Scotia, south to South Carolina and northern Mississippi system.

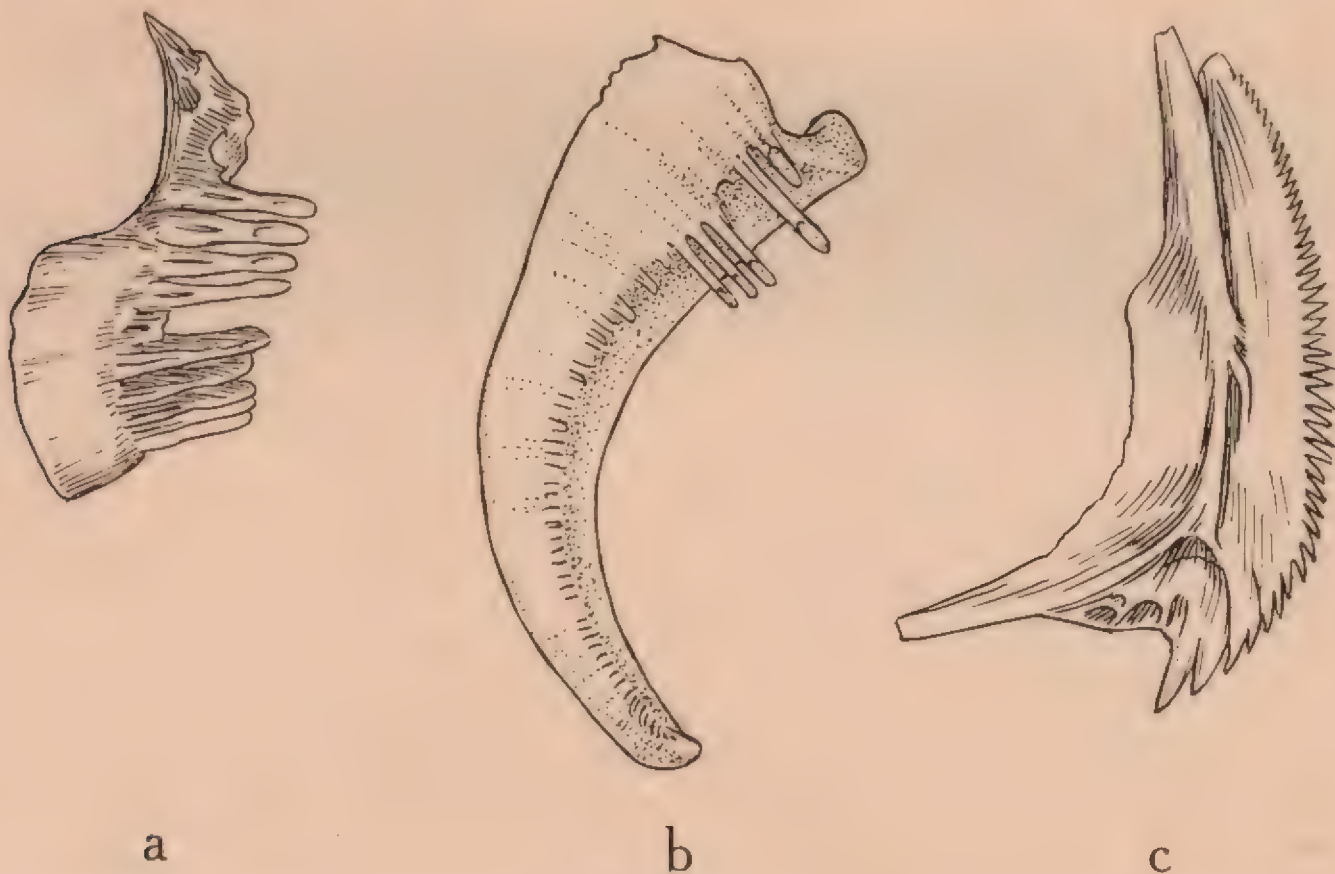


FIGURE 2. a—Posterior surface of right pharyngeal arch of *Catostomus commersonii*;
b—Posterior surface of right pharyngeal arch of *Catostomus catostomus*;
c—External surface of left preopercle of *Perca flavescens*.

Stizostedion vitreum (Mitchill)—walleye

Referred Material: none

Wintemberg (1936) reported remains of this species as yellow pickerel, from the site near Roebuck. Found at present from the Peace-Mackenzie system, Hudson Bay, the Great Lakes and northern Mississippi drainages, and northern Atlantic coast waters to the St. Lawrence and southern Quebec.

SIGNIFICANCE OF THE FISH FAUNA

Of the eight forms found in the old village sites, seven are found there today. One form, the buffalo fish, is found about 250 miles from the nearest present record of a species of the genus and 400 or more miles from the other species. Possibly this species had achieved a more northerly distribution during the hypsithermal period but has since retreated south. The fish fauna would therefore indicate a climate similar to or slightly warmer than that of the present day. That the climate was not widely different from the climate of today is confirmed by the presence of beaver and deer remains. Other boreal mammals (except bison) and agricultural products such as corn, beans, squash and sunflower seeds, reported by Wintemberg at the site near Roebuck, are now found in the same area. The bison found by Wintemberg are about 125 miles north of the closest record of this species at Syracuse, New York. The latter find would tend to support the contention that the climate was slightly warmer than it is today.

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A COLLECTION OF OCEANIC FISHES FROM OFF BRITISH COLUMBIA WITH A DISCUSSION OF THE EVOLUTION OF BLACK PERITONEUM

By D. E. McALLISTER

An unusual collection of oceanic fishes from about 340 miles west of Union Island, Kyuquot Sound, Vancouver Island, B.C. (Lat. 50° N., Long. 135° W.), is described in this paper. The fishes were collected in a 6-foot Isaac-Kidd Trawl between the surface and 60 metres depth in July 1959 by the Pacific Biological Station of the Fisheries Research Board of Canada. A discussion of the function of the black peritoneum found in these fishes is included at the end of the paper. Aron (1959) reports on the fauna of this area, but without descriptions. The author is grateful to Mr. R. LeBrasseur of the Station for the specimens.

ARGENTINIDAE

Argentinidae is here used in the expanded sense of Hubbs (1953).

Bathylagus ochotensis Schmidt 1938

Standard length 111 mm; head length 23.9 mm; predorsal length 50 mm; eye 7.9 mm; greatest depth 19.9 mm; preanal length 84 mm. Dorsal rays 11; anal rays 15; pectoral rays 10-10; ventral rays 11-10; branchiostegal rays 2-2; gill rakers 8 + 1 + 16. Although the scales were worn off, 46 scale pockets could be distinguished along the lateral line. Pyloric caecae 11. Single row of small sharp teeth on vomer, palatines, and dentary. Operculum striated, the striations extending slightly beyond the posterior edge as spines. Operculum with black spot. Body light except for faint dark blotches along the back. Buccal cavity, including tongue, and peritoneum black.

The proportions, shape, and meristic characters, except the pectoral ray count, agree closely with the figure and description presented by Schmidt (1950) of a Sea of Okhotsk specimen. As the pectoral fin was damaged in Schmidt's specimens, this difference is of no consequence.

Nansensia candida Cohen 1958

Standard length 70.8 mm; head length 16.9 mm; predorsal length 36.7 mm; depth of body 8.0 mm. Dorsal rays 11; anal rays 10; pectoral rays 12-13; ventral rays 9-10; branchiostegal rays 3-3; gill rakers 11 + 19. Pyloric caecae 9. Scales lost and uncountable, about 45 myomeres. Single row of small sharp teeth on vomer, palatines, and dentary. Dorsal origin behind midpoint of body. Mouth region dark, body lightly sprinkled with melanophores, becoming darker toward the base of the caudal fin. Buccal cavity pale, peritoneum black.

This specimen agrees very closely with the type description and figure presented by Cohen (1958).

MALACOSTEIDAE (MELANOSTOMIATIDAE)

Aristostomias scintillans (Gilbert) 1915

Standard length 127 mm; head length 31.0 mm; head depth 28.8 mm; predorsal length 101 mm; snout 8.5 mm; eye diameter 6.6 mm; lower jaw length 29.0 mm; enlarged lower jaw tooth length 5.0 mm; barbel length (tip broken off) 29.0 mm. Dorsal rays 23; anal 27; pectoral (damaged) 5-5; caudal 10 + 10 — 10 + 7 (dorsal minor + dorsal major and ventral major + ventral minor rays); branchiostegal rays 13 + 3 and 12 + 3, the 3 lower being larger and flattened; no gill rakers present; pelvic fins and skin missing. Upper jaw teeth 6. Lower jaw teeth 10 + denticles on maxillary. Lower jaw teeth expanded and sharp at tip with a posterior barb. Palatine teeth 4, small sharp. Basibranchial teeth long, sharp, in two rows of six. Upper but no lower pharyngeal teeth. Four gill arches, the slit behind the last reduced. Two short pyloric caecae. Stomach long, extending almost whole length of coelomic cavity; dark dorsally and anteriorly. Large oval posterior suborbital photophore present, and thin "L"-shaped anterior suborbital photophore present. Two or three photophores at the base of each pectoral fin. Pectoral rays with thickened and possibly luminous structures between basal portion of rays. Because of loss of skin, lateral photophores absent except for a series of ten, extending posteriorly from the 16th ray of the anal fin, with six above the hind portion of the anal, three on the lower caudal peduncle, and one at the base of the caudal.

The short snout, deep head, numerous anal rays of this specimen appear to differentiate it from *A. grimaldii* Zugmaver of the North Atlantic as described by Parr (1927). A description of Koefoed's (1956) new species, *A. brattströmi*, of the North Atlantic disagrees in proportions and dentition.

Tactostoma macropus Bolin 1939

Three specimens. Standard length 116, 108, 90 mm; head length 11.0, 11.7, 7.0; teeth in upper jaw 29, 25, 29; teeth in lower jaw 36, 38, 36; dorsal rays 14, 16, 16; anal rays 18, 19, 18; pelvic rays 9, 8, 8. First gill arch with 12 clumps of teeth on the ceratobranchial, one clump on lower portion of the epibranchial. Four gill arches, small aperture behind the last. Long slender teeth on jaws and in two rows on the tongue. Barbels broken, about equal to eye diameter. Skin and peritoneum black. Large round posterior suborbital photophore. An elongate photophore under the front portion of the eye. A large median dorsal photophore just anterior to the eyes, with a diameter about half of the pupil. A photophore immediately in front of the eye.

The specimens agree fairly closely with the type description (Bolin, 1939). Mead and Taylor (1953) compare Japanese, British Columbian, and Californian specimens. Our specimens agree with Californian rather than with Japanese material in the well-developed dorsal median photophore, the dorsal and anal ray counts, and the presence of a clump of teeth on the epibranchial. The elongate organ under the eye extends only below the anterior portion, thus agreeing with the Japanese specimens, rather than the Californian. Eastern Pacific specimens hence appear to be differentiated from western Pacific by a well-developed dorsal median photophore,

epibranchial teeth, and fewer dorsal and anal rays. When further central and western Pacific material is studied, these characters may prove to be of subspecific or specific importance.

MYCTOPHIDAE

Diaphus theta Eigenmann and Eigenmann 1890

Two specimens of 51 and 57 mm standard length which agree closely with Clemens' and Wilby's (1949) description of *D. rafinesquii* (Cocco) (which = *D. theta*). Buccal cavity and peritoneum black.

Lampanyctus leucopsarus (Eigenmann and Eigenmann) 1890

Five specimens with standard lengths ranging from 21 to 75 mm. Buccal cavity and peritoneum black.

Tarletobeania crenularis ? (Jordan and Gilbert) 1880

Three female specimens. Standard length 73.5, 49.2, 48.6; Pre photophores 1, 1, 1; AOa 10, 10, 11; left and right AOp 5-5, 4-5, 4-4; dorsal rays 10, 14, 11; pectoral rays 13, 14, 14; ventral rays 8, 8, 8; anal rays 17, 18, 15 (fins in poor condition). Buccal cavity and peritoneum black.

As these specimens are female, it is not possible to positively assign them to either *T. taylori* of Mead (1953) or to *T. crenularis*. Comparison of meristic and photophore counts with those in Wisner (1953) indicates a closer relation to *T. crenularis*, so they are provisionally identified with this species.

EVOLUTION OF BLACK PERITONEUM IN OCEANIC FISHES AND IN HERBIVOROUS CYPRINIDAE

Despite the phylogenetic differences between the fishes reported on herein, they all shared one feature in common, the possession of black peritoneum. The possession of black peritoneum in deep-sea and bathypelagic fishes is not uncommon. It is found, among others, in Zoarcidae, Macrouridae, Gonostomatidae, and Brotulidae. Burke (1911) found black peritoneum in Cyclogasteridae (= Liparinae) dwelling between 35 and 2,000 fathoms but principally between 200 and 1,000 fathoms. Hjort (1911) also noted the relation between depth and coloration. Hjort's belief that this coloration was associated with the limits of penetration of light was shown by Burke not to be in full agreement with the facts. Further black peritoneum is found in some shallow water fishes such as *Mallotus*, *Alosa*, and *Boreogadus*.

Another, quite unrelated, freshwater group of fishes has dark peritoneum. It is quite well known that phytophagous Cyprinidae usually have dark peritoneum, while zoophagous Cyprinidae have silver or speckled peritoneum (see Hubbs and Black 1947). Black peritoneum occurs in several genera of unrelated phytophagous cyprinids.

When a character recurs in unrelated organisms that have similar habits, one suspects that the feature is an adaptation to that habit (for example curved beaks and talons in raptorial birds). Evidence suggesting

that black peritoneum is not non-adaptive is found in the cave fishes. Cave fishes are characteristically without pigment. This may be explained by (a) the lack of function of pigment in dark caves and (b) the fact that the development and maintenance of chromatophores require a significant amount of energy and material, the loss of which is a selective disadvantage. Hence it may be deduced that black pigment on the peritoneum of oceanic fishes and phytophagous cyprinids probably has some function and is not due to chance nor is it a physiological by-product.

It is hypothesized that the function of black pigment in both of these two groups is to prevent (by absorption) the transmission of light through the body wall. The source and direction of the light absorbed in the two are different, however. Much of the food of bathypelagic, deep-sea, and some shallow water fishes consists of luminescent plankton and nekton. If it were not for the black pigment, this luminescent food would shine through the side of the fish (as these fishes are usually small). This food luminescence could readily reveal the fish's position to a predator. In fishes with a luminescent diet and a thin body, there is, therefore, a selective advantage in having black peritoneum.

Black peritoneum in phytophagous cyprinids may be explained in the basis that light is detrimental to the digestion of plant material. The black pigment in these forms would then be preventing the penetration of *external* light (sunlight) to the intestine. Light may be detrimental to plant digestion either by destruction of commensal bacteria (most of which are killed or inactivated by light) used in digesting celluloses or by destruction of an enzyme such as cellulase or carbohydrase (The latter has been suggested by Hubbs, 1957.). Margolis (1953) failed to find commensal bacteria in *Ictalurus nebulosus* and *Salvelinus fontinalis* and believes the evidence for their occurrence in fish to be poor. It may be noted, however, that most of the forms investigated have not been predominantly phytophagous, so that further investigation should not preclude the effect of light on bacteria.

The hypothesis that black peritoneum is used to prevent light transmission through the body wall economically explains the occurrence of black peritoneum in two ecologically unrelated groups of fishes.

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THE ORIGIN AND STATUS OF THE DEEPWATER SCULPIN, *MYOXOCEPHALUS THOMPSONII*, A NEARCTIC GLACIAL RELICT

By D. E. McALLISTER

INTRODUCTION

In the deep, cold waters of the series of great glacial lakes that stretch across North America from the southeast to the northwest is found an intriguing species of fish, the deepwater sculpin, *Myoxocephalus thompsonii*. Although it has been long realized that this form was a relict of the high Arctic, circumpolar, marine species, the fourhorn sculpin, *Myoxocephalus quadricornis* (Linnaeus), no detailed comparison of the two forms has been published. Because of this, the deepwater sculpin has been variously placed taxonomically, as *Trigloopsis thompsonii*, as *Myoxocephalus* (*Trigloopsis*) *thompsonii*, as *Myoxocephalus thompsonii*, and as *Myoxocephalus quadricornis thompsonii*. This paper discusses the morphology, ecology, taxonomic status, origin, and evolution of the deepwater sculpin and compares it with its progenitor, the fourhorn sculpin. The relationship of the deepwater sculpin to European relicts of *M. quadricornis* is also discussed.

ACKNOWLEDGMENTS

The author is deeply indebted to Dr. W. B. Scott and Dr. E. J. Crossman of the Royal Ontario Museum for the loan of material of *Myoxocephalus thompsonii* which made possible the completion of this study; to Dr. E. L. Bousfield who criticized the manuscript and checked the comments on invertebrates; to Dr. L. P. Schultz of the U.S. National Museum and Dr. R. M. Bailey of the University of Michigan Museum of Zoology who also kindly loaned specimens.

Synonymy of *Myoxocephalus thompsonii*

The following synonymy lists the principal references to *Myoxocephalus thompsonii*. Only the author, date, and page are cited. The full citation is given under the list of references at the end of the paper.

Trigloopsis thompsonii (the original spelling gave an *ii* ending; some later authors have dropped the second *i*). Girard 1852, pp. 65, 66, 67, 71, description, osteology, illustrations (off Oswego, Lake Ontario, New York); Girard 1854¹, p. 19, description (off Oswego); Jordan 1876, description (and in the many subsequent editions); Jordan and Gilbert 1882, p. 709, description, distribution; Bollman 1890, p. 225 (Torch Lake, Michigan); Jordan and Evermann 1898, p. 2005, description, synonymy, distribution; Evermann and Kendall 1901, p. 488 (Nine Mile Point and small creek, Lake

¹ This paper, which bears the date 1851, has been considered as the original description. However, according to Speirs (1951) it was published in 1854. Hence Girard's 1852 paper must be considered as the original description (which is fortunate in that its description is more complete).

Ontario); Evermann and Kendall 1902, p. 216 (Nine Mile Point and small creek, Lake Ontario); *not* Evermann and Goldsborough 1907, p. 111 (75 miles north of York Factory), which refers to the fourhorn sculpin; Nash 1908, p. 103, description; Ruthven 1909, p. 331, distribution, predators (east coast Isle Royale, Lake Superior); Scharff 1911, zoogeography; Jordan and Thompson 1910, pp. 76–78, description, comparison with *T. ontariensis* and *T. stimpsonii*; Halkett 1913, pp. 32, 103, in part, excepting record 75 miles north of York Factory, Hudson Bay; Pratt 1923, p. 142, description; Hubbs 1926, pp. 73, 74, description, synonymy (Great Lakes except Erie); Dymond 1926, pp. 90, 91, description, food, predators (Lake Nipigon); Fish 1928, pp. 77, 78, larvae (Lake Erie); Greeley 1928, p. 179 (Lake Erie); Dymond, Hart and Pritchard 1929, pp. 32, 33, depth distribution, reproduction (Lake Ontario); Hubbs and Brown 1929, p. 53 (Lake Superior, Lake Huron, Lake Ontario); Jordan, Evermann and Clark 1930, p. 389, listed; Fish 1932, p. 385, larvae, description, illustrations (Lake Erie); Berg and Popov 1932, p. 152, taxonomy; Toner 1933, distribution (Georgian Bay); Pratt 1935, p. 133, description; Toner 1937, distribution; Schrenkeisen, 1938, p. 270; Deason 1938, depth distribution (Lake Michigan); Greeley 1940, p. 81 (off Sodus Bay, Lake Ontario); Taranets 1941, p. 433, classification; Hinks 1943, p. 83, listed (Manitoba); Eddy and Surber 1943, p. 228, description; Radforth 1944, pp. 86, 87, distribution map, zoogeography (Ontario); Hubbs and Lagler 1947, p. 97, distribution, figure; Dymond 1947, p. 30, key; Hubbs and Lagler 1949, p. 97, distribution, figure; Hubbs and Lagler 1949a, p. 128, distribution, figure; Berg 1949, pp. 1126, 1135, taxonomy; Rawson 1951, distribution, predators (Great Slave Lake, Reindeer Lake); Wynne-Edwards 1952, p. 21; Scott 1954, p. 113, description, distribution, life-history, figure; Keleher and Kooyman 1957, p. 111 (Reindeer Lake); Underhill 1957, p. 31, zoogeography; Moore 1957, p. 202, distribution; Scott 1958, p. 24, listed; Bertin 1958, p. 1918; Slastenenko 1958, p. 9, listed; Slastenenko 1958a, pp. 335, 336, description, distribution, synonymy, figures; Wilimovsky and Lanz 1959, p. 9 (trans. of Taranets, 1941). [*Triglopsis*—appearance of *Trigla*; *thompsonii*—after Rev. Z. Thompson, author of History of Vermont].

Triglopsis thompsoni Carlander 1950, p. 216 (*lapsus calami*).

Ptyonotus thompsonii Günther 1860, p. 175, description (*Ptyonotus*, a substitute name for *Triglopsis* on the presumption that *Triglopsis* was pre-occupied by *Triglops*). [*Ptyonotus*—fan, back, in allusion to the high second dorsal fin].

Myoxocephalus (Triglopsis) thompsoni, Eddy 1957, p. 232, description, distribution, figures.

Myoxocephalus thompsoni, Walters 1955, pp. 318, 347, taxonomy, zoogeography.

Myoxocephalus quadricornis thompsonii, Nickolsky 1954, p. 366, relationship; Hubbs and Lagler 1958, pp. 3, 117, 118, distribution, figure.

Triglopsis stimpsoni Hoy 1872, p. 99, *nomen nudum* (Lake Michigan off Chicago); Jordan and Evermann 1898, p. 2005, synonymize with *T. thompsonii*; Jordan and Thompson 1910, p. 77, description, figure; Jordan, Evermann and Clark 1930, p. 389, listed; Berg 1949, p. 1135, taxonomy [*stimpsoni*—after Dr. William Stimpson, secretary of the Chicago Academy of Science, crustaceologist].

Myoxocephalus quadricornis, Jacoby 1953, pp. 1-23, life-history notes (Lake Superior).

Trigloopsis ontariensis Jordan and Thompson 1910, pp. 75, 76, description, figure; Halkett 1913, p. 104, listed, distribution; Hubbs 1926, p. 74, synonymized with *T. thompsonii*; Jordan, Evermann and Clark 1930, p. 389, listed; Berg 1949, p. 1135, taxonomy. [*ontariensis*—after Lake Ontario].

Cottus quadricornis, Ekman 1953, p. 173, distribution, map; de Beaufort 1951, p. 25, zoogeography.

The Progenitor of *Myoxocephalus thompsonii*

There are no species of sculpins closely related to the deepwater sculpin in freshwater. The genus *Cottus* is trenchantly different in the form of the preopercles, the juncture of the gill membranes with the isthmus, the scutellation of the sides, and the type of lateral line (although some European ichthyologists still employ *Cottus* for marine sculpins in the Linnæan sense). Study of marine cottids shows that the deepwater sculpin should be placed in the genus *Myoxocephalus* and that it is most closely allied to *Myoxocephalus quadricornis*, the fourhorn sculpin. Both *quadricornis* and *thompsonii* have four preopercular spines, while other species of the genus normally have three (*M. scorpius* sometimes develops a fourth spine). Both *quadricornis* and *thompsonii* display sexual dimorphism in the pectoral and soft dorsal fins, unlike other species in the genus. The soft dorsal fin of mature males is elongated, and the rays of this fin and the pectoral bear numerous, tiny, rough tubercles. A further difference has been found in the preoperculo-mandibular sensory canal. In both *thompsonii* and *quadricornis*, pores are minute on the mandible, and the pores on the preopercle are prolonged into tubelike cirri (those in *thompsonii* are longer). In all other species of *Myoxocephalus* examined (*octodecimspinosus*, *aneus*, *scorpius*, *scorpioides*, and *polyacanthocephalus*), mandibular pores are larger, and those on the preopercle are not prolonged into tubes.

Possibly these characters would justify subgeneric separation of *thompsonii* and *quadricornis* from other species of *Myoxocephalus*. If so, the name *Trigloopsis* Girard 1852 is available and has priority over *Oncocottus* Gill 1862. However, it seems unwise to apply subgeneric names until the whole genus is reviewed.

Morphological Comparison of *M. thompsonii* and *M. quadricornis*

METHODS

Measurements were taken with vernier calipers accurate to 0.1 mm. Measurements and counts were made on the left side unless that side was injured. Standard length was measured to the caudal flexure. The length of the uppermost preopercular spine was taken from its distal tip to apex of the angle between the upper spine and the one below it. The position of the various spines discussed is depicted in Figure 2. All the dorsal, anal, and pectoral rays were counted (the ultimate and penultimate dorsal and anal rays were on separate basals). Chi square tests were used to evaluate the significance of the differences and percentage separation to evaluate the

taxonomic usefulness of the difference. (Although a difference may be highly significant, it may not necessarily be taxonomically useful.) The percentage separation was calculated by dividing the number of identifiable individuals of both species, using that character, by all the specimens of both species (See p. 100 of Mayr, Linsley, and Usinger, 1953).

Sixty-six specimens of *thompsonii* from over its whole range (see Figure 3) were compared with sixty-three specimens of *quadricornis* from Arctic America. The samples of *thompsonii* were drawn from every lake it was found in, except Lake Erie and Torch Lake. The samples of *quadricornis* came from the following localities—Alaska: Collinson Point; Northwest Territories: Mould Bay, Prince Patrick Island; Walker Bay, Victoria Island; Bernard Harbour; Repulse Bay, Melville Peninsula; Slidre Fjord, Ellesmere Island; Ponds Inlet, Baffin Island; Quebec: Stupard Bay; Ungava Bay; Labrador: Nain Harbour; Jerusalem Bight, north of Hebron Harbour; James Bay: Akimiski Island; Attawapiskat River. The lengths of the specimens employed may be obtained from Figure 1.

The sample sizes in the following tables are not always the same. Some specimens were damaged, and not all characters could be ascertained on a specimen. (Some of the *thompsonii* were obtained from stomach samples.) The following paragraphs discuss the characters by which it was found possible to differentiate the fourhorn and the deepwater sculpin.

The Nearctic distribution of the deepwater and the fourhorn sculpin is shown on the map in Figure 3. The distribution of *quadricornis* was obtained from National Museum collections and from the literature (references summarized in McAllister, 1960). The distribution of *thompsonii* was obtained from the literature, which is summarized in the synonymy, and from records in the Royal Ontario Museum.

PREOPERCULAR SPINES

The length of the preopercular spine was found to be the most diagnostic character. The length of the spine is plotted against standard length in Figure 1. It may be seen that the dashed line between the two forms separates all the specimens, with no overlap.

It may also be seen that there is an inflection separating the relative growth rates into two stanzas in both species. After the inflection, the relative growth rate of the spine decreases. The inflection occurs at about 100 mm in *thompsonii* and at about 95 mm in *quadricornis*. In both growth stanzas, the relative growth rate is slower in *thompsonii* than in *quadricornis*.

The difference in size of the preopercular spine may be expressed as a ratio of the spine length divided by the standard length. As a single ratio cannot take into account the inflection, only 96 per cent of the specimens can be separated in this manner (see Marr, 1955). The preopercular spine is shorter in *thompsonii*, its length always comprising less than 4.6 per cent of the standard length; in *quadricornis* its length is usually 4.6 per cent or more of the standard length. The values for this character in the two species are given in Table 1. It may be seen from the probability figure of $-.001$ that the difference is highly significant. The reduction in length is also apparent in the other preopercular spines, although they were not measured.

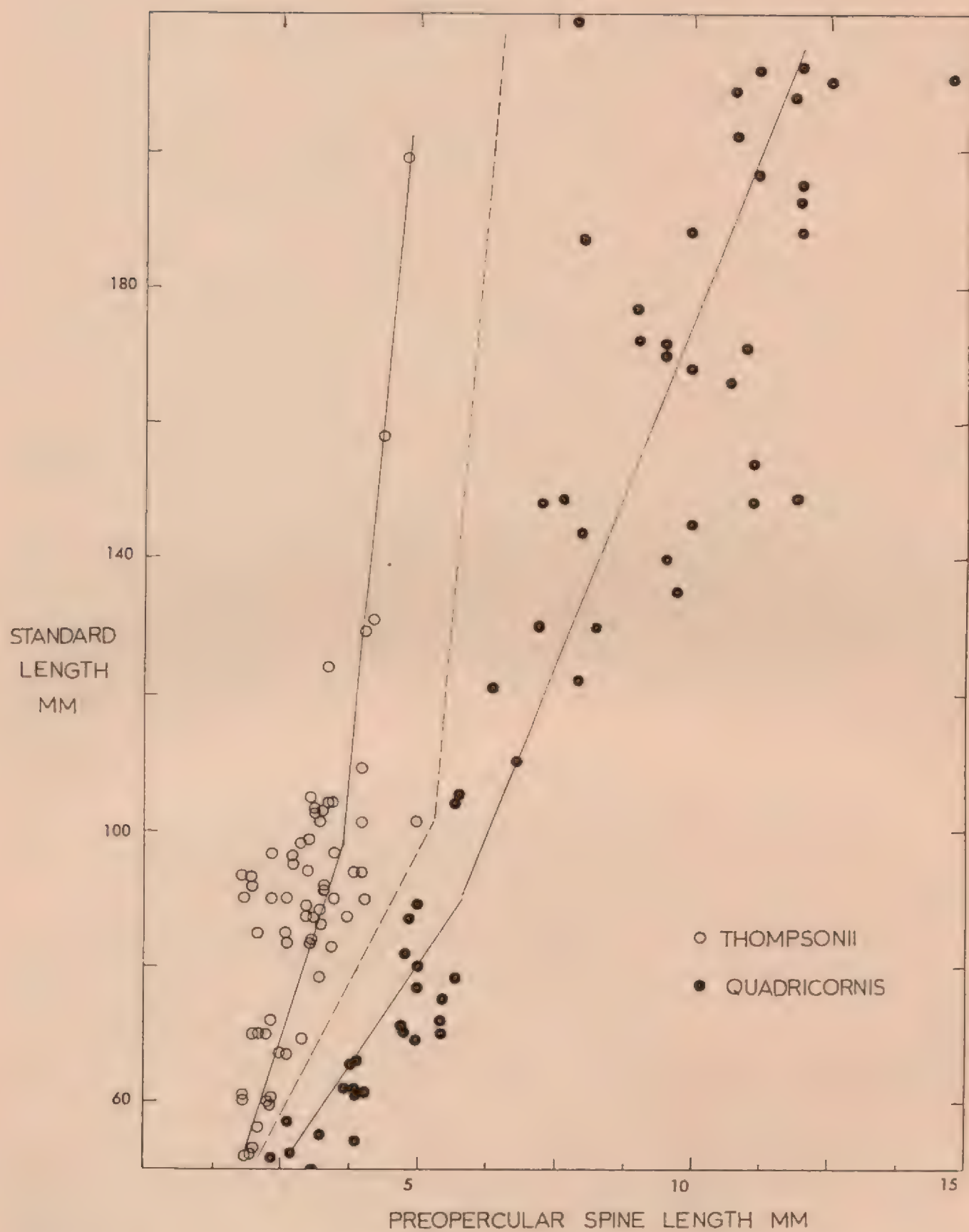


FIGURE 1. Preopercular spine length plotted against standard length in *Myoxocephalus thompsonii* and *M. quadricornis*. Note the dashed line showing the absence of overlap in this character.

TABLE 1

Preopercular Spine Length/Standard Length (As a Percentage)

Species	Length of Preopercular Spine	
	4.5% or less	4.6% or more
<i>thompsonii</i>	64	0
<i>quadricornis</i>	5	56 $p = -.001$

OTHER SPINES

The frontal (supraorbital), parietal (occipital), and cleithral spines also exhibit differences (see Figure 2 for the location of these spines). Usually these spines were absent in *thompsonii* and present in *quadricornis*. When fully developed in *quadricornis*, the frontal and parietal spines become club-shaped, and their upper surfaces develop numerous spinules. Occasionally the nasal and cleithral spines also develop spinules in *quadricornis*. The frontal and parietal spines are not fully developed in all specimens until a standard length of about 70 mm is reached. Even slight development of the frontal spines makes the interorbital space concave in *quadricornis*, while it is flat in *thompsonii*. In a very few speci-

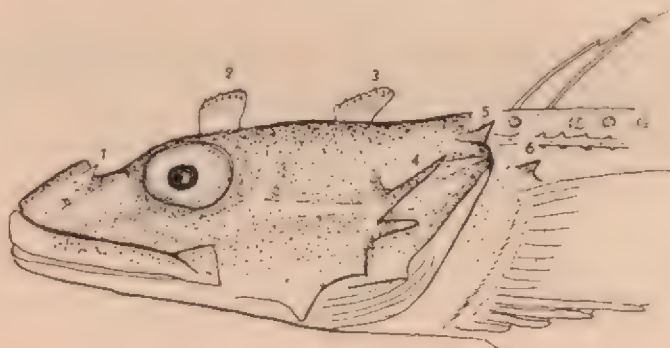


FIGURE 2. Lateral view of head of *Myoxocephalus quadricornis* showing the following spines: (1) nasal, (2) frontal, (3) parietal, (4) preopercular, (5) supra-cleithral, (6) cleithral.

mens of *thompsonii*, very low, blunt, unclub-like, non-scabrous frontal and parietal spines are developed. Such a specimen was the basis for *Triglops ontariensis* and is figured by Jordan and Thompson, 1910. Using frontal spines, 86 per cent of all of the specimens may be distinguished; using parietal spines, 83 per cent of all of the specimens may be distinguished; using cleithral, 91 per cent. Table 2 gives the numbers of specimens bearing these spines. Plus sign denotes presence of a spine, minus sign the absence. The probabilities indicate that the differences between the species in each of the spines are highly significant.

TABLE 2
Number of Specimens With Frontal, Parietal, and Cleithral Spines

Species	Frontal		Parietal		Cleithral	
	+	-	+	-	+	-
<i>thompsonii</i>	3	63	6	60	11	55
<i>quadricornis</i>	51	13	48	15	62	1
	p = -.001		p = -.001		p = -.001	

TUBERCLES

Although the skin is mostly naked in the two species, there are small disk-like tubercles bearing posteriorly directed spinules scattered about the skin of the sides. The number of tubercles and their spininess and distribution are considerably reduced in *thompsonii*.

Tubercles were never found below the lateral line in *thompsonii*. Tubercles were usually found below the lateral line above the front half of the anal fin in *quadricornis* (except in seven out of the ten specimens from Labrador and one out of the six specimens from James Bay with none). The number of tubercles below the lateral line varied from 1 to 41 in *quadricornis*, usually numbering 5 to 20. The difference in tuberculation below the lateral line is highly significant as indicated by the probability value of -.001. Table 3 presents the variation in this character. With this, 93 per cent of all the specimens could be identified.

Tubercles are found above the lateral line from the nape to the caudal peduncle in both species. There are usually much fewer tubercles in *thompsonii*, and the tubercles are usually distributed in one row instead of in two as in *quadricornis*. Using the number of tubercles above the lateral line, 90 per cent of all of the specimens could be identified. The probability figure of -.001 indicates that this difference is highly significant. Table 3 presents the variation in the number of tubercles.

TABLE 3
Number of Tubercles

Species	Number above the lateral line		Number below the lateral line	
	0-30	31-100	0	1-41
<i>thompsonii</i>	50	5	55	0
<i>quadricornis</i>	7	56	8	55
	p = -.001		p = -.001	

LATERAL LINE

The lateral line is better developed in *thompsonii*, being longer, larger in diameter, and more protuberant. The diameter of the lateral line is about equal to the diameter of the pupil in *thompsonii*, about half the diameter of the pupil in *quadricornis*. The lateral line usually extends past the insertion of the second dorsal fin and is often complete in *thompsonii*. The lateral line seldom extends past the insertion of the second dorsal fin in *quadricornis*. Using this character, 69 per cent of all the specimens can be identified. Table 4 presents the variation in this character. The difference is shown to be highly significant by the probability value of $-.001$. It was noted that the tube-like cirri through which the sensory pores on the preoperculum opened were longer in *thompsonii* than in *quadricornis*, although this character was not quantified.

TABLE 4
Extension of the Lateral Line

Species	Does not extend past end of second dorsal	Extends past end of second dorsal
<i>thompsonii</i>	11	43
<i>quadricornis</i>	37	25

p = $-.001$

PECTORAL RAYS

All the fin rays were examined for differences between the two forms, but only the pectoral rays were found to be useful. *M. thompsonii* usually has more pectoral rays, 16 to 17 (15 to 18), than *quadricornis*, 15 to 16 (14 to 17). Since female *quadricornis* tend to have more rays than male, the sexes of the two species are compared separately in Table 5. Using pectoral ray counts, 70 per cent of the females and 78 per cent of the males are separable. The significance of these differences are high, the probability equalling .01-.001, and $-.001$ respectively.

TABLE 5
Pectoral Fin Ray Counts

Species	Number of Pectoral Fin Rays				
	14	15	16	17	18
<i>thompsonii</i> ♀.....	—	2	8	12	—
<i>quadricornis</i> ♀.....	1	4	20	6	—

p = .01-.001

<i>thompsonii</i> ♂.....	—	1	13	18	3
<i>quadricornis</i> ♂.....	1	14	15	—	—

p = $-.001$

OTHER RAYS

Although the dorsal spine, dorsal ray, and anal ray counts exhibited average differences, these differences were not great enough to employ in identification. Only the difference between anal rays was found to be significant, and this only just significant. The ray counts for the species are included in Table 6.

TABLE 6
Comparison of Other Fin Ray Counts

Species	Dorsal Spines					Dorsal Rays							Anal Rays					
	6	7	8	9	10	10	11	12	13	14	15	16	11	12	13	14	15	16
<i>thompsonii</i>	—	15	28	9	1	—	3	13	20	11	4	1	1	13	17	14	6	1
<i>quadricornis</i>	1	14	36	9	—	1	1	7	21	23	6	—	—	4	18	30	6	1
	p = .7 to .5					p = .10 to .05							p = .05 to .02					

MAXIMUM LENGTH

Although the maximum length cannot be considered of taxonomic value in allopatric populations, it is included for the sake of its ecological significance. The largest specimen of *thompsonii* examined, which exceeds any reported in the literature, is one 199 mm (7.8 inches) in standard length from off Bowmanville in Lake Ontario (R.O.M. 8740). Deason (1938) reported the largest one examined from Lake Michigan to be 109 mm standard length. The largest *quadricornis* in our collection is one of 230 mm (9.0 inches) standard length from Collinson Point, Alaska (NMC 58-81). Andriashev (1954) records *quadricornis* up to 365 mm in the U.S.S.R. It is interesting to note that the northwestern specimens of *thompsonii* are all quite small, the largest being 69 mm standard length from Christie Bay, Great Slave Lake. This is in agreement with the known slower growth rate of species from northwestern lakes as compared with those in the Great Lakes (see, for example, Kennedy 1954 of the lake char).

SEXUAL DIFFERENCES

The deepwater sculpin and the fourhorn sculpin have several sexually dimorphic features. The soft dorsal fin is much higher and the other fins only slightly higher in the mature male than in the female (see fig. 573 and 574 in Eddy, 1957). The rays in the front of the soft dorsal and the upper portion of the pectoral bear small, hard, rough tubercles in the males. Female specimens of *quadricornis* tend to have more pectoral rays (see Table 5). Walters (1955) found that the frontal spines averaged higher than the parietal spines in male *quadricornis*. There was no correlation between presence and absence of these spines with sex in our material of *quadricornis*. No significant differences between males and females of either species were found in the number of dorsal spines, the dorsal and anal rays, or the number of tubercles.

SUMMARY OF MORPHOLOGICAL CHARACTERS AND KEY

The following key summarizes the major differences between the two species. It might also be mentioned that *thompsonii* is paler, has longer preopercular cirri, has a more prominent lateral line, and does not attain so great a size as *quadricornis*.

As shown in Figure 1, all the specimens can be separated using preopercular spine length. Using any of several other characters, most of the specimens can be separated. The taxonomic significance of these differences is discussed below.

- 1 (2) Tubercles always absent below the lateral line; usually 30 or fewer tubercles above the lateral line. Preopercular spine short, length 4.5 per cent or less of standard length. Nearly always lacking cleithral, frontal, and parietal spines. Frontal and parietal spines, if present, never large, club-shaped or scabrous. Lateral line usually extends past the insertion of the second dorsal. Pectoral rays usually 16 to 17.....
.....deepwater sculpin—*Myoxocephalus thompsonii* (Girard)
- 2 (1) Tubercles nearly always present below the lateral line; usually 31 or more tubercles above the lateral line. Preopercular spine long, length usually exceeds 4.5 per cent of the standard length. Usually with cleithral, frontal, and parietal spines. Frontal and parietal spines usually large, club-shaped and scabrous. Lateral line does not usually extend past the insertion of the second dorsal. Pectoral rays usually 15 to 16.....
.....fourhorn sculpin—*Myoxocephalus quadricornis* (Linnaeus)

INTRASPECIFIC DIFFERENCES IN THE DEEPWATER SCULPIN

Although this is primarily an interspecific study, some comments on intraspecific differences are perhaps pertinent. No great differences between the populations of the different lakes were noticed. Although there is a hiatus of about 700 miles between the Great Lakes drainages and the arctic drainages of the northwest, no differences (except that of size, already mentioned) were found between them that were not equalled by differences within the drainages (See Figure 3, where it may be noted that the northwestern lakes form a drainage unit. Lac La Plonge, Wollaston Lake, Reindeer Lake, and Lac La Ronge all flow into the Churchill River system, which flows into Hudson Bay. Lac La Martre and Great Slave Lake, although flowing into the Mackenzie which drains into the Beaufort Sea, are connected to Wollaston Lake through Slave River, Athabasca Lake, and a small tributary, the Black River). An apparent difference in the Great Lakes area is the high number of tubercles above the lateral line in Lake Nipigon (22 to 50) and the low number in Lake Ontario (0 to 14). Lake Michigan and Lake Superior populations lie between these values. However, larger series of specimens will have to be examined before any conclusions can be drawn. A detailed intraspecific study of *M. thompsonii* using larger collections would be of interest.

Ecological Comparison of *M. thompsonii* and *M. quadricornis*

REPRODUCTION

The deepwater sculpin is a summer spawner. Dymond, Hart and Pritchard (1929) found large masses of nearly ripe eggs in specimens from Lake Ontario in early August. Specimens from Port Credit, Lake Ontario (ROM 3628A), collected July 18, 1927, contained ripe gonads. One of these, a male, had a large clump of eggs in its mouth. Marie Poland Fish (1928)

reported young in Lake Erie 12.5 to 27.5 mm on July 30, 16 mm on August 9, and 12.5 to 14 mm on August 10, from 20 to 60 metres depth. These are doubtless young of the year. (Jacoby's (1953) paper was not seen.)

The fourhorn sculpin is reported to spawn from June to September in Arctic North America (Johansen MS.). East Greenland specimens were found to be ripe on August 25 by Johansen (1912). There appears to be a different spawning time in the Palearctic. Smitt (1893) reports spawning from November to January in Scandinavia. Andriashev (1954) reports spawning in later autumn and winter for the U.S.S.R. The freshwater relicts of *quadricornis* in the Palearctic are also found to spawn in the winter, Smitt (1893) reporting November for Swedish relicts and Berg (1949) reporting January to beginning of February for *M. quadricornis lönnbergi*.

DEPTH AND TEMPERATURE

The deepwater sculpin, as its name indicates, is an inhabitant of deep waters. In Lake Michigan it ranges from 25 to 100 fathoms (usually 40 to 75) (Deason 1938); in Lake Ontario from about 50 to 68 fathoms (Dymond, Hart and Pritchard, 1929); in Lake Nipigon specimens were found in stomachs of *Lota lota* that had been caught at depths of from about 12 to 20 fathoms (Dymond 1926); and in Great Slave Lake they have been collected from one-half fathom to 230 fathoms (usually at 50 to 75 fathoms) (Rawson 1951). The usual depth span over the whole range of the species varies therefore from 40 to 75 fathoms. The maximum annual range of temperature at these depths probably ranges from 0° to 14°C.

Unlike the deepwater sculpin, the fourhorn sculpin is a shallow water species. According to National Museum records, it seldom occurs deeper than 10 fathoms in Arctic North America. Johansen (1912) found a similar distribution in east Greenland. According to Andriashev (1954) it rarely extends deeper than 7 to 10 fathoms. The fourhorn sculpin may be found at surprisingly high temperatures, up to 12°C. (lagoon, Martin Point, Alaska, NMC 58-109) or even 14° to 15°C. (Bathurst Inlet, N.W.T., Walters 1955). The low salinities (*see below*) of its habitat probably do not permit winter temperatures to descend below -1° or -1.5°C.

The similarity of the habitat temperature of the two species might be explained by the selection of the warmest temperature in its environment by the fourhorn sculpin and by the selection of the coldest temperature in its environment by the deepwater sculpin. The selection for a preferred temperature range results in different depth distributions of the two species.

SALINITY

The deepwater sculpin is found only in freshwater. The fourhorn sculpin is found in brackish water and not infrequently in fresh. According to Walters (1955) the fourhorn sculpin is seldom, if ever, found in sea water of full strength. It has been reported up the Mackenzie about 120 miles at Arctic Red River (Preble, 1908) and up the Meade River in Alaska 80 to 90 miles (Murdoch, 1885). These points indicate the fourhorn sculpin to have a high tolerance to freshwater, although there are no records of its spawning there. According to information in Segerstråle (1957), *quadricornis* is not known at salinities above 24‰ or above 6‰ in the Baltic (where its history indicates it has twice adapted to freshwater).

LIGHT

The amount of light that young receive during development has been shown to be an important factor. The deepwater sculpin inhabits a geographical zone receiving from 1,800 to 2,200 mean annual total hours of sunshine (675 to 825 in June, July, and August); the fourhorn sculpin zone of 1,600 or less (550 to 675 in June, July, and August) according to values calculated from Thomas (1953). Modifying the amount of light received is the depth of water. The depth of water over the deepwater sculpin may reduce the quantity of light to which it is exposed to the same or less than that to which the fourhorn is exposed.

PREDATION

The deepwater sculpin is known to be subject to predation by only two species, the ling (*Lota lota*) and the lake char (*Salvelinus namaycush*) (Girard, 1852; Rawson, 1951; Scott, 1954; Dymond, 1926; Deason, 1938, and other authors). Because of the great depth it inhabits, it is unlikely that any other species preys on it to a significant degree. On the other hand, the fourhorn sculpin is subject to predation by many species. Several of our Alaskan specimens were obtained from the esophagus of a Mew Gull (*Larus canus oxyrhynchus*). Richardson (1836) reports it as "... abundant on the east side of the peninsula of Boothia, affording a plentiful supply of food to the numerous water-fowl which breed there." The shallowness of its habitat doubtless makes it particularly subject to bird predation. Johansen (MS.) records this species from the stomachs of whitefish, *Lota lota*, *Myoxocephalus scorpius*, and *Lycodes*. There is one record in our collection from the stomach of a *Salvelinus alpinus* (Bernard Harbour, NMC 58-94). One specimen is taken from the stomach of another fourhorn sculpin (NMC 58-108). The list of predators of this species will probably be augmented as our knowledge of the Arctic increases. However, even from present knowledge it may be seen that the fourhorn sculpin is more subject to predation than the deepwater sculpin.

FOOD

The food of the deepwater sculpin has been little studied. Dymond (1926) reported its food in Lake Nipigon to consist principally of *Pontoporeia hoyi* (= *P. affinis*) and chironomid larvae. The author found *Mysis relicta*, *Pontoporeia affinis*, and chironomid larvae in Port Credit, Ontario, specimens.

Johansen (1912) found the east Greenland diet of the fourhorn sculpin to consist of crustaceans (amphipods and *Mysis oculata*); (MS.) in Arctic America to include *Pseudalibrotus littoralis* (very frequently), *Mesidotea entomon* (isopod), *Gammarus locusta* (probably = *G. setosus*) (amphipod), *Mysis oculata* (mysid), chironomid larvae, *Laminarea*, and other seaweeds. Walters (1953) found annelids, fish eggs, and small crustaceans in Mould Bay, N.W.T. specimens. The food of Palearctic sculpins reported by Andriashev (1954) is not notably different: *Mesidotea*, fish to a small degree (smelt, *Elginus navaga*), and amphipoda (*Pseudalibrotus*, *Pontoporeia*, *Gammarus*).

It is interesting to note that all items of food reported for the deepwater sculpin are also found in the diet of the fourhorn sculpin.

Evaluation of the Differences

In allopatric forms it is not possible to use the criterion of reproductive isolation to determine taxonomic status (where experiment is not feasible). In order to decide whether the difference between the two forms is of specific or subspecific value, it is necessary to determine how completely the forms can be separated, whether the morphological differences are attributable to hereditary or environmental factors, and lastly how the difference compares with interspecific differences between other species in the same genus.

All the specimens of the two forms can be separated (usually at a glance). This degree of difference is characteristic of species, not subspecies. Such a difference alone does not necessarily prove specific distinctness.

Experimental work summarized by Tåning (1952) and Lindsey (1958) has demonstrated that differences during development in temperature, salinity, and light may produce differences in meristic characters. However, none of these experiments, although the extremes of the factors tested have approached the lethal limits, have produced differences which were non-overlapping. Thus experimental evidence would suggest that the differences between the two forms were too great to be produced by environment.

The fourhorn sculpin has free access to freshwater and actually enters it. Significantly, despite this, no freshwater fourhorn sculpin populations have been produced which might be confused with the deepwater sculpins. In this respect it may be noted that Walters (1955) found a specimen from Meade River to have well-developed cranial clubs and to be identical in appearance with adult coastal fishes from Point Barrow. It is likely that in the wide range of the fourhorn sculpin other environmental conditions of the two species would be approximated. The James Bay populations of the fourhorn sculpin are more than 200 miles south of the northwestern populations of the deepwater sculpin. Despite this, all the specimens of the two species can be separated. It therefore seems likely that the morphological differences between the two forms are attributable to hereditary characters.

In order to compare the distinctness of the deepwater and the fourhorn sculpin with the difference between two other accepted species in the same genus, a table from data in Walters (1955) is presented comparing *Myoxocephalus scorpioides* with *M. scorpius groenlandicus* (sympatric Arctic species).

<i>M. scorpioides</i>	<i>M. scorpius groenlandicus</i>
Pectoral with 14 to 16 rays.	Pectoral with 17 to 18, seldom 16 rays.
Top of the head roughened by numerous hard and sharp-tipped warty protuberances.	Top of head relatively smooth; warty protuberances not numerous.
Frontal and parietal spines weakly developed, covered by thick skin in adults.	Frontal and parietal spines well developed, blunted, frequently with one or more small accessory spines at their bases.
Stout cirrus present on each frontal and parietal spine.	Cirri often absent in adult fish; when present short and slender.
Caudal peduncle relatively long and slender.	Caudal peduncle relatively shorter and stouter.

It may be seen that most (if not all) of the characters separating *M. scorpioides* and *M. scorpius groenlandicus* overlap or are subjective. Further overlap is apparent when European specimens of *M. scorpius* are considered (only American material is compared in the above table). Upon comparing the table above with the key, it will be seen that the differences between the deepwater sculpin and the fourhorn sculpin compare favourably with the differences between *M. scorpioides* and *M. scorpius groenlandicus*.

Because the deepwater sculpin may be completely separated from the fourhorn sculpin, because the differences between the deepwater sculpin and the fourhorn sculpin appear to have a hereditary basis and compare favourably with those between other species in the genus, it is concluded that the deepwater sculpin, *Myoxocephalus thompsonii*, is a valid species, distinct from the fourhorn sculpin, *Myoxocephalus quadricornis*.

Relationship of *Myoxocephalus thompsonii* to European Relicts

Relicts of *Myoxocephalus quadricornis* are also found in lakes of Sweden, Finland, and adjacent Russia. It is necessary to consider these forms in relation to the deepwater sculpin. The European relicts have been taxonomically treated by Berg and Popov (1932) and Berg (1949). Segerstråle (1956, 1957) treats the distribution and origin of glacial relicts of *M. quadricornis* and other species in this area.

Berg (1949) has reduced the many named relicts of *M. quadricornis* to *M. q. lönnbergi* Berg 1916 and *M. q. relictus* (Lilljeborg) 1891. A third form, *onegensis* Berg and Popov 1932, is treated as a natio of *M. q. relictus* (in the key) and as a subspecies of *M. quadricornis* (in the text). Other forms with latin names are also listed. It is evident from Berg (1949) that these subspecies are poorly differentiated and that the populations in the different lakes vary because of different degrees of degeneration. However, these forms, like *thompsonii*, are characterized by reduction in lateral tuberculation and in cephalic armature.

Unfortunately, the descriptions of European relicts do not provide us with adequate information on the characters which most concern us. It is thus difficult to determine exactly how similar Nearctic and Palearctic relicts are. However, *lönnbergi* appears to be separated from *thompsonii* by the possession of frontal, parietal, and cleithral spines and more numerous tubercles; *relictus* may also be separated on the basis of cleithral and cephalic spines. As remarked by Berg and Popov (1932), *onegensis* is most similar to *Triglops stimpsoni* (= *M. thompsonii*). However, at least some specimens of *onegensis* bear parietal spines and their fig. 886 shows it to bear a cleithral spine, thus differentiating it from the North American relict. The European relicts seem to have degenerated less from *M. quadricornis* than has the North American relict and hence are still morphologically separable from that species.

One last piece of evidence definitely suggests a different origin of North American and European relicts of *M. quadricornis*. The spawning of North American *M. quadricornis* and *M. thompsonii* occurs during the summer months, while that of European *M. quadricornis* and its European relicts is in the winter. This not only suggests that *thompsonii* was derived from North American *M. quadricornis*, but provides reproductive isolation

between *thompsonii* and European *relicts*. Hence, even if the North American and Nearctic relicts are not morphologically separable, they must be considered specifically different (by Mayr, Linsley, and Usinger's (1953) definition). Even if the spawning differences should not prove valid and the Palearctic and Nearctic relicts be found to be the same, the name *thompsonii* would apply, since it has priority over any of the names applied to Palearctic relicts.

Origin and Evolution of *Myoxocephalus thompsonii*

One of the most intriguing problems regarding *Myoxocephalus thompsonii* is that of its origin. How did its marine ancestors come to be isolated in freshwater? Three hypotheses suggest themselves: (1) that they were left stranded in lakes by a retreating marine invasion of the land; (2) that they entered freshwater of their own accord; and finally that they were pushed up onto land in sea-water dammed in front of the advancing ice-sheet. These hypotheses will be considered in turn.

Hoy (1872) was the first to advance the hypothesis that the deepwater sculpin was a marine relict. Scharff (1911), believing that the deepwater sculpin was a marine relict from a Hudson Bay marine invasion of the Great Lakes, also propounded this theory. It is an attractive theory when we consider that Lake Nipigon is less than 350 miles from James Bay. However, as is shown in Figure 3 by the heavy line, marine waters from Hudson Bay did not advance as far as the Great Lakes. An alternative theory is that they were brought into or to Lake Ontario by the invasion of the sea up the St. Lawrence valley. Postglacially, the Champlain Sea and the Ottawa Sea (Hough 1958 proposes a modified terminology) extended up the valley of the St. Lawrence (see maps in Canada 1957 or Lougee 1953). There is controversy whether these marine invasions actually entered the Lake Ontario Basin (see discussion by Lougee, 1959). Nevertheless the invasion provided a potential path for marine ancestors to enter the Great Lakes.

However, strongly against this theory of introduction by marine invasions up the St. Lawrence (and from Hudson Bay) is the fact that they occurred during the hypsithermal period (Flint 1957, p. 347). As the hypsithermal period was warmer than it is now and as *M. quadricornis* at present only extends south to northern Labrador, it is unlikely that *quadricornis* then ranged far enough south to enter the St. Lawrence River. Introduction by marine invasions into the great lakes of northern Canada also seems unlikely from Figure 3 (see also Richards, 1950). A further argument against introduction by postglacial marine invasions is the element of time. The lapse of about 7,000 years or less since the marine invasions is well below the time requirement generally considered necessary for speciation. It may also be noted that Ricker (1959) does not call on marine invasions to explain the origin of relicts of *Mysis* and *Pontoporeia* derived from salt-water forms. Also, if marine invasions had taken place, one might well have expected that many other marine organisms (examples given further on) would have become adapted to freshwater. To summarize, none of the evidence now at hand supports the theory that *Myoxocephalus thompsonii* is a marine relict.

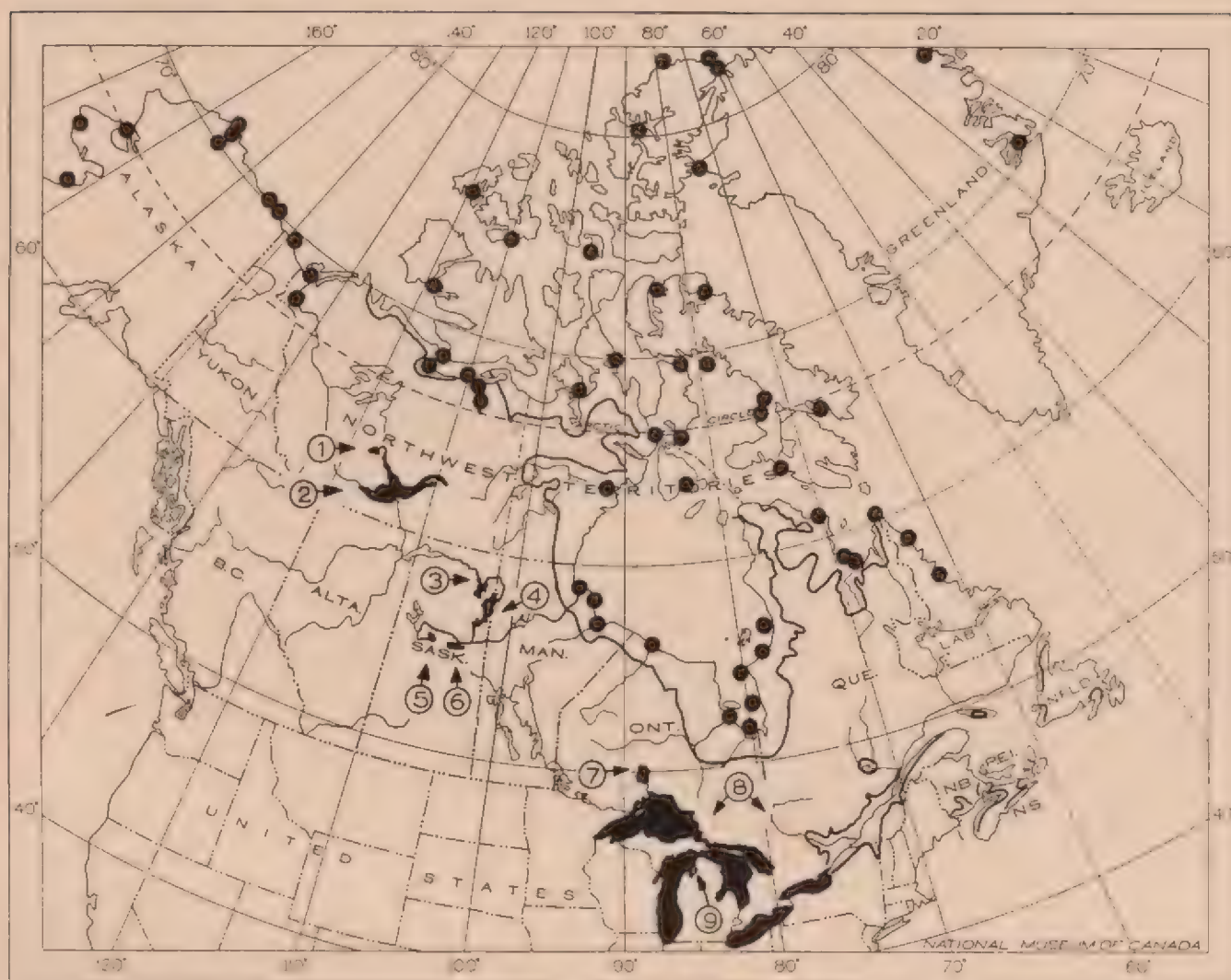


FIGURE 3. The distribution of *Myoxocephalus thompsonii* (black lakes) and *Myoxocephalus quadricornis* in North America (black circles). The dark line (from Canada 1957, Atlas of Canada) shows the extent of marine invasions. The numbered lakes are (1) Lac La Martre, (2) Great Slave Lake, (3) Wollaston Lake, (4) Reindeer Lake, (5) Lac La Plonge, (6) Lac La Ronge, (7) Lake Nipigon, (8) the Great Lakes, (9) Torch Lake.

The second theory, proposed by the author, is that the ancestors of the *M. thompsonii* (a form identical with or similar to the present *M. quadricornis*) entered freshwater of their own accord; i.e., they were not carried in masses of sea-water onto the land by marine invasions or in front of the ice, but "voluntarily" swam into freshwater as they are now known to do. Examples have already been mentioned where *M. quadricornis* were collected far from the sea in the Mackenzie and Mead rivers. It is suggested that at the beginning of the Wisconsin glaciation, when isotherms were further south, sculpins similarly moved up the St. Lawrence to Lake Ontario or up the Albany River (which drains into James Bay and connects directly with Lake Nipigon flowing into the Great Lakes) or lastly into the Churchill River. (The amount of differentiation between *thompsonii* and *quadricornis* and the lack of subspecies in *thompsonii* does not call for its origin much earlier than the Pleistocene.) In all these situations the advancing glacial sheet (as indicated by glacial striae on map 15, Canada 1957) would result in the southern movement of the freshwater populations into the great glacial lakes centring about Lake Winnipeg (Lake Agassiz) or about the Great Lakes (Lake Algonquin). In these glacial lakes during

the glacial period with few predators, the new species *thompsonii* would evolve. Dispersal would occur along the front of the glacial sheet in the resulting lakes. Consequent restriction of range to a few deep cold lakes would result following glaciation as lakes warmed and became unsuitable.

A very similar third theory of entrance into freshwater, suggested by Radforth (1944) for the origin of *thompsonii*, was the driving south of sculpins by the glacier in a body of sea-water. This involves the pushing up by the glacier of a mass of sea-water over the land. The sea-water gradually becomes diluted by freshwater, slowly adapting the organisms in it to freshwater. This theory had already been proposed by European biologists. It is modified, adapted to explain the North American origin of relicts of *Pontoporeia* (*P. affinis*) and *Mysis* (*M. relicta*) and called the proglacial lake theory by Ricker (1959). This theory adequately and economically explains the origin and present distribution of these two forms. It is interesting to note that these two invertebrates occur together with *Myoxocephalus* in the sea and as freshwater relicts, indeed in both situations these invertebrates form the food of *Myoxocephalus*. In every lake where *thompsonii* occurs (where the presence of the invertebrate has been searched for), both invertebrates have been found; they also occur in many lakes where *thompsonii* is not found. Although this may only indicate similar ecological requirements, it may be well to consider common origin.

It is difficult to decide which of the last two theories is more acceptable. It is helpful to consider the case of the relicts in the Baltic area. Relicts of at least eight species having marine or brackish water progenitors are found in the freshwaters of the Baltic area: the ringed seal, *Phoca hispida*; the fourhorn sculpin relict already mentioned; and relicts of the crustacean genera *Gammaracanthus*, *Pallasea*, *Pontoporeia*, *Mesidotea*, *Mysis*, and *Limnocalanus* (Segerstråle, 1956, 1957). Segerstråle (1957) explained their origin by the "sluicing-up" of salt-water in front of the advancing ice-cap into Onega Ice Lake. (Various further immigrations need not concern us.) This theory, backed up by detailed distributional, geological, and ecological studies, is well accepted by biologists, including Ricker (1959) for the Baltic area. Only four such possible relicts, *Limnocalanus*, *Pontoporeia*, *Mysis*, and *Myoxocephalus*, are found in the Nearctic¹. If a great mass of salt-water had been pushed ahead of the ice in North America, we might expect many more organisms to have been introduced into freshwater, as in the Baltic area, instead of just three. It may be noted that *Mesidotea entomon**, *Pseudalibrotia littoralis*, *Gammaracanthus loricatus**, and perhaps *Pontogeneia inermis* are shallow water species in the Canadian Arctic, tolerant to brackish water which might also have been expected to be introduced into freshwater (species with an asterisk are those which, having become relict in the Baltic area, are of known adaptability to freshwater). It therefore seems suggested that *Pontoporeia*, *Mysis*, and *Myoxocephalus* were not introduced into freshwater in this manner, because other faunal elements, which are lacking, would have been introduced with them (following Mathews' rules regarding land-bridge building).

¹ A relict harbour seal; *Phoca vitulina mellonae*, is known from the Canadian Arctic. However its range, Upper and Lower Seal lakes, western Quebec, is outside that of the other relicts discussed. Further, unlike the discussed relicts, the seal lies within or very close to the edge of the area inundated postglacially from the Hudson Bay. It may have been left in freshwater after this marine invasion (and hence be a marine relict), or it may have entered freshwater of its own accord when the land was lower before upwarping.

It therefore seems more likely that the North American relicts were already in freshwater before the coming of the ice, although this matter is by no means settled. It is clear, however, that present distribution is the result of dispersal in proglacial lakes. As shown by Ricker (1959), their distribution can best be explained by the spread in proglacial lakes ahead of the glacier and following the glacier north as it retreated. Ricker also shows that distribution of relicts is in accordance with the existence of two major ice-sheets, the Cordilleran and the Laurentide. The absence of relicts north of the St. Lawrence valley is ascribable to the lack of proglacial lakes in this region as the glaciers retreated uphill.

From the foregoing it is evident that the deepwater sculpin, *Myoxocephalus thompsonii*, should be termed a glacial relict (not a marine relict).

The evolution of *M. thompsonii* from *M. quadricornis* involved two series of changes, the reduction in armature and the increased development of the lateral line system. The reduction in armature may be attributed to a reduction in predation. In the deep waters of lakes there is no avian predation and predation from only two species of fishes. That spines are effective in deterring predators has been shown experimentally by Morris (1955). Buckland (1880) has reported a grebe and kingfishers killed by the preopercular spines of sculpins (*Cottus gobio*) they tried to swallow. We may therefore see that the reduction in armature is the result of a lowering in selective pressure to maintain large spines and tubercles (which doubtless take significant energy to develop and maintain, particularly in waters of low availability of salts). Similar degeneration is found in the eyes and pigment of cave fishes, the skeleton of deep-sea fishes, and the loss of gas bladders in benthic forms. The development of the lateral line may be understood on the basis of poorer penetration of light to the depths in which *thompsonii* lives. In consequence, there is a selective advantage in having a better developed lateral line to detect prey and escape predators. That the differences between *thompsonii* and *quadricornis* may be understood in evolutionary terms makes it more certain that these traits are genetic and that these fishes are taxonomically distinct.

SUMMARY

2. The deepwater sculpin is shown distinct from European relicts of the tinct from its parent species the fourhorn sculpin, *Myoxocephalus quadricornis*. All specimens of the two species can be identified. The deepwater sculpin is well differentiated by its longer preopercular spine, the poorly developed or absent frontal, parietal, and cleithral spines, the fewer tubercles above the lateral line, the absence of tubercles below the lateral line, and the longer lateral line.
2. The deepwater sculpin is shown distinct from European relicts of the fourhorn sculpin by its reproductive period, if not by its morphology.
3. The ecology of *Myoxocephalus thompsonii* and *M. quadricornis* is shown to be similar, except with regard to depth.
4. The *Myoxocephalus quadricornis* ancestors of *M. thompsonii* either entered freshwater of their own accord ahead of the glaciers or were pushed in a diluting mass of sea-water ahead of the glacier. Evolution

and dispersal occurred in proglacial lakes before the Laurentian ice-sheet. Restriction of distribution to present lakes occurred as the climate warmed and many lakes became unsuitable.

5. The evolution of *Myoxocephalus thompsonii* took place under reduced predation, resulting in the reduced selection for armature and in its consequent degeneration. The evolution of a more developed lateral line system might be attributed to the darker conditions of the depths in which *Myoxocephalus thompsonii* dwells.
6. A key, distribution map, and synonymy are presented.

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SYSTEMATICS OF THE FRESHWATER SCULPINS (*COTTUS*) OF BRITISH COLUMBIA

By D. E. McALLISTER AND C. C. LINDSEY¹

INTRODUCTION

The freshwater sculpins of western North America form an intriguing but perplexing mosaic of forms. Convergent and divergent evolution in the genus *Cottus* confuses the efforts of systematists to distinguish species and to discern relationships among species. Progress must depend on the accumulation of data describing variation in each form over its whole geographic range. Studies by Bailey and Dimick (1949) and Robins and Miller (1957) have done much to clarify the systematics of species in the western United States. The present paper deals with variation in those species of *Cottus* which inhabit British Columbia.

Synonymies are included for the genus and for each species discussed; these include only new taxa, and not further identifications or misidentifications. Following the genus synonymy is a key for identification of all species of *Cottus* known to occur in British Columbia. Each species is provided with a description, and a discussion of variation, based, unless otherwise stated, solely on specimens from British Columbia. Notes on distribution within the province may be supplemented by reference to Carl, Clemens, and Lindsey (1959) who provide more detailed information and distribution maps. Following each species is a brief discussion of its possible affinities. Graphs and tables of morphological characters for British Columbia and some extralimital species are presented in the Appendix.

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METHODS

Measurements were made with vernier calipers. Standard length was taken from the anterior edge of the upper lip to the posterior edge of the hypural plates (as marked by the wrinkle produced by flexing the caudal fin). Head length was measured from the anterior margin of the upper lip to the posterior edge of the opercular bone. Caudal peduncle depth was the shallowest measurement of that part.

Most counts of fin rays, spines, basals, and caudal vertebrae (shown in Figure 2 and Tables 2, 3, 7, 8, 9, 10) as well as descriptions and illustrations of prickles (Figure 3) were made from specimens cleared and stained with alizarin, using the technique of Hollister (1934). Some counts were based on X-ray plates or (particularly in *Cottus cognatus*) on untreated specimens.

Dorsal and anal ray counts followed the methods of Robins and Miller (1957). All dorsal spines were counted separately, even where the first two arose from a single basal. On the other hand, where the last pair of dorsal or anal soft rays arose from a common basal they were counted as one. This procedure was followed so that counts from the literature would be comparable. However, the presence of single or double members at the anterior of the spinous dorsal and at the posteriors of the soft dorsal and anal fins were recorded, and proved to be of systematic significance. (The presence of double rays at the posterior ends of the soft dorsal and anal fins was universal in all species examined, except *Cottus cognatus*, and it is therefore omitted from the descriptions.)

Caudal fin ray counts are presented as a formula: dorsal minor rays + major rays + ventral minor rays, e.g. 7-9 + 12 + 6-8. Major rays are constantly twelve, with six arising from each of the two hypural plates; the uppermost one and lowermost two major rays are unbranched, while the remainder are branched. Minor rays (Table 9), which are smaller and unbranched, lie above or below the major rays and do not arise from the hypural plates. One spine is always present in each pelvic fin, closely bound to the outermost ray. It is distinguishable from the ray only by clearing or dissection.

Branchiostegal ray counts are not presented because they were almost invariably six, and only very rarely seven, in the species examined.

Caudal vertebral counts (Table 10) commenced at the first vertebra whose haemal arch enclosed the caudal vein, and they included the urostyle. Specimens with deformed vertebrae or fins were omitted. Throughout this paper "vertebral count" refers to caudal, not total, vertebral number.

Preopercular spines were counted on the left side of cleared fish. Only eruptions of the preopercular margin into sharp elevations were considered as spines; low bumps were not counted. Spines were enumerated only if the inner and outer ossified plates of the preopercle fused together to form a point.

Terminology of the head sensory canals follows Robins and Miller (1957). Lateral line pore counts commenced at the posterior margin of the operculum. Occasionally specimens with incomplete lateral lines have isolated pores posterior to the rest of the lateral line; these pores were not included in the counts. Except in *Cottus ricei*, lateral line pore counts were recorded only for specimens over 70 mm total length. Pores may not be completely developed in smaller individuals.

The description of each species is based on examination of collections covering the whole known range in British Columbia. The number of specimens of each species studied varied from several dozen to several hundred, depending on the range of the species within the province and the size of the collections available. Specimens are stored in the Museum of the Institute of Fisheries at the University of British Columbia.

CLASSIFICATION AND SYNONYMIES OF THE GENUS *COTTUS*

Family

COTTIDAE

Subfamily COTTINAE

Cottinae Taranetz 1941, Bull. Acad. Sci. U.S.S.R., Biol. Ser., 1941, No. 3, p. 434 (English trans., Mus. Cont. No. 5, Inst. Fisheries, Univ. Brit. Col., 1959).

Genus *Cottus* Linnaeus

Cottus Artedi 1738, Genera Piscium, p. 49.

Cottus Linnaeus 1758, Syst. Nat., ed. 10, fasc. 1, p. 264 (type species restricted to *C. gobio* Linnaeus by Cuvier and Valenciennes, Hist. Nat. Poiss., IV, 1829, p. 142, and by Int. Comm. Zool. Nomen.).

? *Pegedictis* Rafinesque 1820, Ichthyol. Ohiensis, p. 85 (type species, *P. ictalops* Rafinesque which probably = *P. carolinae* Gill, description confused, species not certainly identifiable. *Pegedictis* sometimes altered to the correct orthography, *Pegedichthys*).

Uranidea DeKay 1842, New York Fauna, Fishes, p. 61 (type species, *U. quiescens* DeKay=*Cottus cognatus* Richardson).

Cottopsis Girard 1851, Proc. Boston Soc. Nat. Hist. for 1848, III, p. 303 (type species, *Cottus asper* Richardson).

Potamocottus Gill 1862, Proc. Boston Soc. Nat. Hist. for 1861, VIII, p. 40 (type species, *P. carolinae* Gill).

Tauridea Jordan and Rice 1878, in Jordan, Man. Vert. East. United States, ed. 2, p. 255 (type species, *Cottopsis ricei* Nelson).

Rheopresbe Jordan and Starks 1904, Proc. United States Nat. Mus. 27, p. 269 (type species, *R. fujiyamae* Jordan and Starks).

Cephalocottus Gratzianow 1907, Zool. Anz., XXXI, p. 659 (type species, *Cottus amblystomopsis* Schmidt).

Mesocottus Gratzianow 1907, Zool. Anz., XXXI, p. 660 (type species, *Cottus haitej* Dybowski).

Key to the Species of *Cottus* in British Columbia

- 1 (12) Lateral profile of head rounded. Pre-orbital region protrudes little, if any (Figure 1b). Upper preopercular spine equal to about one-half eye diameter and not strongly curved inwards. Mandibular pores small. Lateral line incomplete, or if complete deflecting downwards on the caudal peduncle.
- 2 (5) One pore on tip of chin. Lateral line complete. Caudal vertebrae 24-28. The first two dorsal spines close together, resting on the same basal.



FIGURE 1. Dorsal view of heads of (A) *Cottus ricei*, (B) *C. cognatus*.

- 3 (4) Anal rays 15-19. Palatine teeth present. Posterior nostrils non-tubular. Two or three preopercular spines. Usually prickles on back and sides, occasionally reduced to behind pectoral. Pectoral rays 15-18. Dark oval spot in posterior spinous dorsal; spinous dorsal with a thin orange edge in both sexes.....
.....prickly sculpin—*Cottus asper* Richardson p.70
- 4 (3) Anal rays 12-14 (rarely more). No palatine teeth. Posterior nostrils tubular. One preopercular spine. Prickles always restricted to small patch behind pectoral fin. Pectoral rays 13-15 (rarely 16). Spinous dorsal lacking dark oval spot; in spawning males with dark median band and broad orange edge.....
.....coastrange sculpin—*Cottus aleuticus* Gilbert p.74
- 5 (2) Two pores on tip of chin. Lateral line complete or incomplete. Caudal vertebrae 20-24. First two dorsal spines no closer together than others, resting on separate basals.
- 6 (11) Prickles restricted to a small area behind the pectoral fin. Head length usually 3 times or more in standard length. Caudal peduncle depth 4.7 times or fewer into head length. Lateral line incomplete or complete. Either three dark bars or none under the second dorsal fin. Underside of head uniformly speckled. Palatine teeth patch absent or short and not in contact with vomerine teeth. Base of prickle not serrated.
- 7 (8) Palatine teeth absent. Anal rays usually 10-12 (rarely 13). Pelvic rays 3-4; when the 4th is present it is usually less than two-thirds the length of the longest. Last two dorsal and anal rays often separated, arising from different basals.....slimy sculpin—*Cottus cognatus* Richardson p. 75
- 8 (7) Palatine teeth present. Anal rays usually 12-14. Pelvic rays 4, the 4th about three-quarters the length of the longest. Last 2 dorsal and anal rays close at base, arising from the same basal.
- 9 (10) Postmaxillary pore double. Head usually 2.9-3.2 times in standard length. Caudal peduncle depth 3.7-4.6 times in head length. Usually 14-16 pectoral rays (sometimes 13). 23-34 lateral line pores. Usually 3 bars on the side under the second dorsal. Three preopercular spines.....
.....Columbia sculpin—*Cottus hubbsi* Bailey and Dimick p.83
- 10 (9) Postmaxillary pore single. Head 3.2-3.9 times in standard length. Caudal peduncle depth 3.2-3.9 times in head length. Usually 13-14 pectoral rays (sometimes 15). 20-24 lateral line pores. Usually without bars on side under second dorsal. Two, sometimes three preopercular spines.....
.....shorthead sculpin—*Cottus* sp. p.84
- 11 (6) Prickles usually extending onto sides and back. Head 3.0 times or fewer in standard length. Caudal peduncle depth 4.8-6.4 times in head length. Lateral line complete. Usually two narrow forward-slanting bars under the second dorsal fin. Underside of head mottled with large and small speckles. Palatine tooth patch long and in contact with vomerine. Base of prickle serrated.....
.....torrent sculpin—*Cottus rhotheus* (Rosa Smith) p.84
- 12 (1) Lateral profile of head flat. Preorbital region, in dorsal view, protrudes almost as far forward as the tip of the snout, giving the border of the head behind the lip a "W" shape (Figure 1a). Upper preopercular spine usually longer than two-thirds of eye diameter and strongly curved inwards. Mandibular pores large. One pore on midline of tip of chin. No palatine teeth. Lateral line complete and reaching base of caudal fin without noticeable deflection.....spoonhead sculpin—*Cottus ricei* (Nelson) p. 85

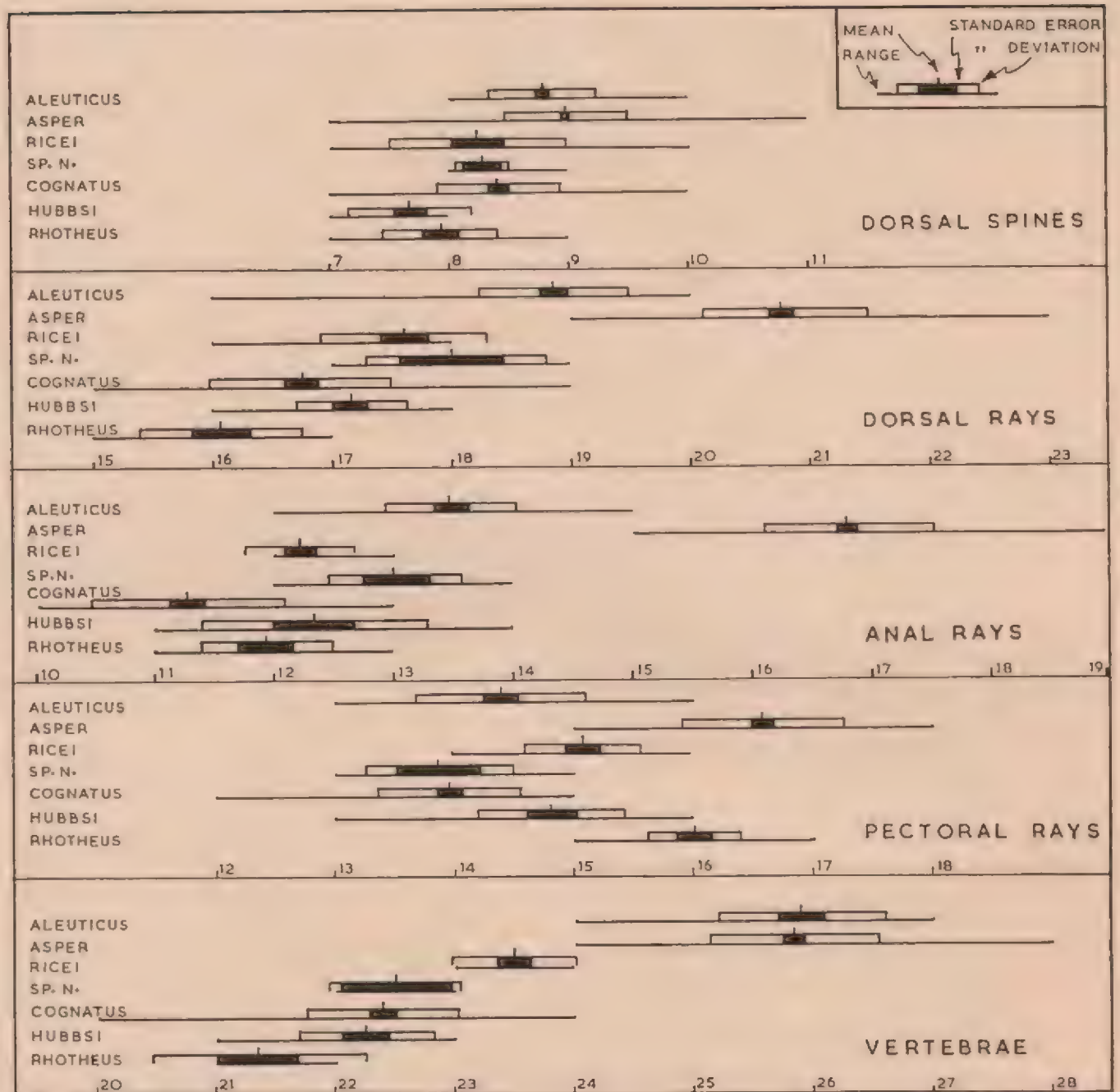


FIGURE 2. Meristic variation in specimens of *Cottus* examined from British Columbia.

DESCRIPTIONS OF THE SPECIES

***Cottus asper* Richardson 1836**

prickly sculpin

Cottus asper Richardson 1836, Fauna Boreali-Americana, III, Fishes, p. 295, Columbia River at Ft. Vancouver (now Vancouver, Washington).

Trachidermis richardsoni Heckel 1840, Ann. Wiener Mus., p. 162, based on Richardson's description (not *Cottus richardsoni* Agassiz which is *C. bairdii*).

Cottopsis parvus Girard 1854, Proc. Acad. Nat. Sci. Philadelphia, VII, p. 144, Presido, California.

Description. D_1 7–10 (11); D_2 19–23; C 7–11 + 12 + 5–11 (14); A 15–19; P 15–18; V I, 4 (I, 3–5); Vert. 24–28; L.L. 32–43. Maximum length 180 mm in B.C., 300 mm elsewhere. Head large, 2.7–3.5 in standard length. Caudal peduncle depth medium, 4.0–5.1 times in head, .06–.08 of standard length. Mouth large (see Northcote, 1954). Posterior nostril not tubular. Strong teeth on palatine bones; palatine tooth patch not in contact

with vomerine tooth patch (Northcote 1950). Spines on the preopercle either three (27 specimens) or two (9 specimens). Prickling variable, restricted to axil or extending over the whole body (except abdomen). Prickles with long sharp shaft and flat or tridentate base (see Figure 3). Two spines arise from the first dorsal fin basal. Preoperculo-mandibular pores usually 10-1-10 (one median pore on tip of chin, postmaxillary pore double); infraorbital pores usually nine, sometimes eight. Lateral line usually complete, occasionally lacking on the caudal peduncle. Length of straight portion of lateral line on peduncle posterior to downward deflection equal to about $1\frac{1}{2}$ times eye diameter. Genital papilla of females, small and round; of males a long "V".

Usually three dark bands under the second dorsal fin. Chin lightly covered with fine speckles. First dorsal fin with faint central pigmented band, which is concentrated in the posterior region forming a characteristic dark oval spot; posterior dorsal edge of first dorsal with thin band of orange in both sexes. Males become dark in spawning season.

Distribution. From Chilkoot Lake, southeastern Alaska to Ventura River lagoon in southern California. There are several records from brackish water. In British Columbia found in the Columbia, Fraser, Dean, Skeena, Nass, and Stikine river systems, as well as in the headwaters of the Peace River and numerous coastal lakes and streams. Further details of British Columbia distribution may be obtained from Carl, Clemens, and Lindsey (1959). The present distribution suggests that the prickly sculpin survived south of glaciation on the Pacific Coast. Its wide range may be attributed in part to its tolerance of brackish water.

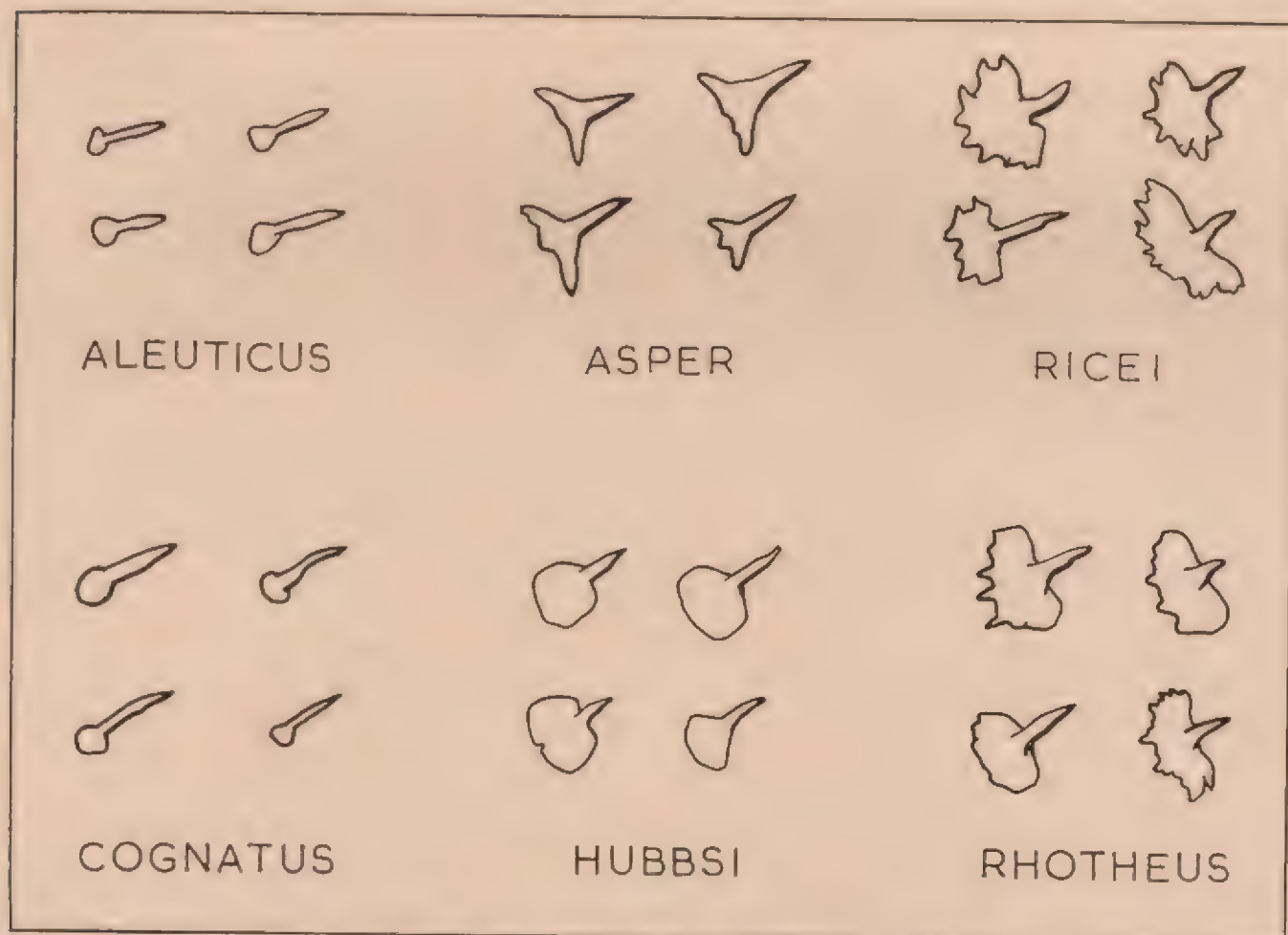


FIGURE 3. Prickle form in British Columbia species of *Cottus*, drawn from stained and cleared specimens.

Intraspecific Variation. Populations of *Cottus asper* living close to the sea differ morphologically from inland populations. In studying this phenomenon, collections have been classed as "coastal" (10 miles or less from the sea) or "non-coastal" (from 25 to 65 miles from the sea). Collections from farther inland have been omitted to avoid the effect of major climatic differences. Specimens are from the lower Fraser and Skeena systems, short coastal drainages, certain inshore islands, and Vancouver Island.

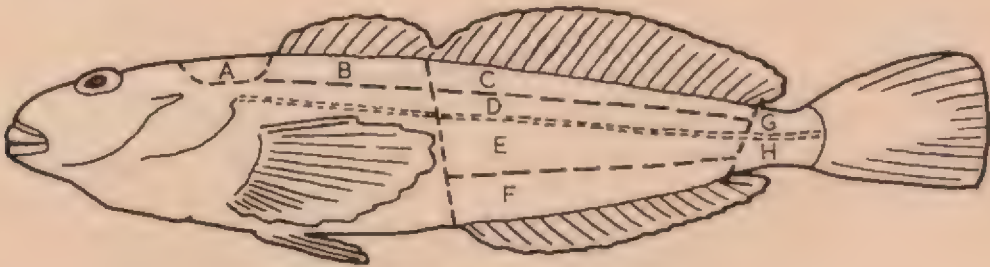


FIGURE 4. Areas of prickling in *Cottus asper*.

On each specimen, presence or absence of prickling was recorded for each of the areas of the body shown in Figure 4. Table 1 presents the percentage of individuals bearing prickles in each area.

TABLE 1
Percentage of Individuals Prickled on Different Body Areas in Coastal and Non-Coastal *Cottus asper*

Region	Body Area Prickled								Mean	Sample Size
	a	b	c	d	e	f	g	h		
	%	%	%	%	%	%	%	%	%	
Coastal (13 collections)	0	23	63	83	77	13	35	29	40.3	52
Non-coastal (8 collections) . . .	69	86	91	91	94	77	91	77	84.5	35

Chi-square tests showed these differences to be significant in areas a, b, g, h ($p=.001$); area c ($p=.01-.001$); area e ($p=.01-.05$); but not in area d ($p=0.1-0.2$). Furthermore, coastal sculpins not only were less often prickled in certain body areas, but were also found to have less dense prickling in those areas containing some prickles.

TABLE 2
Variation in Meristic Characters in Coastal and Non-Coastal *Cottus asper*

Region	Dorsal Rays					Pectoral Rays			Caudal Vertebrae				
	19	20	21	22	23	15	16	17	24	25	26	27	28
Coastal (14 collections)	2	22	47	7	1	12	49	19	1	11	55	14	—
Non-coastal (9 collections)	3	15	33	17	—	2	23	42	—	2	28	32	2

Table 2 presents meristic characters of coastal and non-coastal specimens. Again there are significant differences between the two types, in caudal vertebrae and pectoral rays ($p=.001$), and in dorsal rays ($p=.01-.05$). Dorsal spines and anal fin rays did not differ significantly.

Morphological differences between coastal and non-coastal *C. asper* are probably correlated with behavioural differences. Hunter (1959) states that in Hooknose Creek, B.C., *C. asper* moves downstream and spawns in the intertidal region (where the eggs are probably washed by water which was brackish, if not fully saline). Similarly, in California, Shapovalov and Taft (1954) report that sexually mature prickly sculpins migrated downstream through a counting fence close to the sea at Waddell Creek. Sumner (1952) also reported that prickly sculpins were caught in a downstream trap just below the head of tidewater during spring and early summer (the spawning period) at Jewell Creek, Oregon. Downstream spawning migration, which has been reported from widely separated points, is probably, therefore, common in coastal populations. On the other hand, populations from farther inland apparently do not migrate long distances to the coast. For example, a population at Hatzic Lake, about 50 miles from the sea in the lower Fraser valley, is known to spawn in freshwater streams.

The morphological differences described above may be attributable to genetic factors (as, presumably, are the behavioural differences), or they may be due to the phenotypic effect of environmental differences (notably in salinity) where the two types of eggs develop. Study of these sources of variability between the two forms of sculpin will have to depend on experimental rearing under controlled conditions.

An obvious parallel is suggested between *C. asper* and the threespine stickleback *Gasterosteus aculeatus*. In the latter species, exhaustively studied by Heuts (1947), two types exist, one anadromous and one freshwater. The former has a well-developed set of lateral scutes, lives in the sea, but enters the lower reaches of rivers to spawn; the latter has few scutes and passes its entire life in freshwater. Genetically-determined physiological differences (in temperature and salinity tolerance) have been shown between eggs of the two types of stickleback. The case of *C. asper* differs in that one population may be catadromous rather than anadromous, and this rather than the freshwater form is less heavily invested with dermal armour. Divergence between the two forms of *Cottus asper* is evidently less than between the two forms of *Gasterosteus aculeatus*.

Examination of published data and of specimens from British Columbia reveals a distinct tendency for increase in the number of dorsal spines toward the north. Mean counts rise quite regularly from 8.34 at 38°N. to 9.11 at 56°N. Dorsal and anal rays, pectoral rays, and caudal vertebrae present more irregular patterns. Within one population, Northcote (1950) found no significant differences between the sexes in numbers of dorsal spines or dorsal or anal rays.

Affinities. *Cottus princeps* appears to be related intimately to *Cottus asper*. These species share a high vertebral count (Table 10) and high total dorsal basal count (Table 8), well-developed prickling, and a single pore on the tip of the chin (Table 6). *Cottus aleuticus* is also close to *asper* in having a high vertebral count, a single pore on the tip of the chin, and two spines on the first dorsal basal (Table 7).

Cottus aleuticus Gilbert 1893**coastrange sculpin**

Uranidea microstoma Lockington 1880, Proc. U.S. Nat. Mus., III, p. 58, St. Paul, Kodiak Island, Alaska (name preoccupied by *Cottus microstomus* Heckel).

Cottus aleuticus Gilbert 1893, Rept. U.S. Fish. Comm., XIX, p. 418, streams at Unalaska, Alaska.

Cottus protrusus Schultz and Spoor 1933, Copeia, No. 3, p. 142, Unalaska Island, Alaska.

Description. D_1 8-10; D_2 (16) 17-20; C 6-9 + 12 + 6-9; A 12-15; P 13-15 (16); V I, 4; Vert. 24-27; L. L. 34-44. Total length up to 115 mm. Head and mouth small, head entering standard length 3.0-3.5 times. Caudal peduncle deep, entering head 3.3-4.7 times, comprising .072-.083 of standard length. Posterior nostrils (unlike other B.C. species) distinctly tubular. (As they often lie back flatly, one has to lift them to determine if they are tubular.) No teeth on palatine bones. One preopercular spine. Weak prickles restricted to a small area behind the pectoral. Prickles with a long shaft and a small base (Figure 3). Two spines arise from the first dorsal fin basal. Preoperculo-mandibular pore count 10-1-10 (one median pore on tip of chin; postmaxillary pore double); infraorbital pore count 9. Lateral line usually complete. (We do not agree with Bailey and Dimick (1949) that this species has an incomplete lateral line.) Length of straight portion of lateral line on peduncle following the downward deflection about equal to eye diameter. Anal papilla longer in male than in female. This species, like all other North American species of the genus, lacks tubercles on the pelvic fins. Evermann and Goldsborough (1907) described some Alaskan specimens of *Cottus aleuticus* as bearing pelvic tubercles. Examination of their specimens (U.S. National Museum No. 60749) showed the "tubercles" to be encysted parasites.

Three mottled bars lie under the second dorsal fin. Chin lightly and evenly speckled. Often a prominent light bar across top of peduncle. Spawning male darker with broad orange edge on the first dorsal fin, remainder of fin black.

Distribution. Bering Sea to northern San Luis Obispo County, California. Although mainly coastal, it occurs 300 miles inland in the Skeena River system and well over 100 miles inland in the Fraser system. In British Columbia it is known from the Fraser, Skeena, and Nass drainages, as well as from many coastal streams and lakes. Tolerates brackish water. Further British Columbia distribution may be obtained from Carl, Clemens, and Lindsey (1959). *Cottus aleuticus* probably survived glaciation south of the ice-sheet and redispersed northward through fresh and brackish waters.

Geographic Variation. Coastal and non-coastal samples were examined from differences in dorsal spines, dorsal rays, anal rays, pectoral rays, and caudal vertebrae, and prickling, as in *Cottus asper*. Only pectoral rays (Table 3) were found to be significantly different (probability .05-.02). Shapovalov and Taft (1954) found that *Cottus aleuticus* also performed downstream migrations toward the sea in Waddell Creek, California. With only one morphological difference, there seems less likelihood of there being two hereditarily distinct populations.

TABLE 3
Pectoral Ray Counts in Coastal and Non-Coastal *Cottus aleuticus*

	13	14	15	16
Coastal.....	3	12	7	0
Non-coastal.....	2	8	15	2

Affinities. *Cottus aleuticus* is similar to *Cottus princeps* and *Cottus asper*. As discussed previously, these three species have in common high vertebral and dorsal basal counts, and a single chin pore. *C. princeps* would appear to be more intimately related to *C. aleuticus* than to *C. asper*, because it shares with the former a lack of palatine teeth and possession of only one preopercular spine.

***Cottus cognatus* Richardson 1836**

slimy sculpin

Cottus cognatus Richardson 1836, Fauna Boreali-Americana, III, Fishes, p. 40, Great Bear Lake, Northwest Territories.

Cottus gracilis Heckel 1837, Ann. Wien. Mus., II, p. 148, New York.

Cottus viscosus Haldeman 1840, Suppl. Mongr. Linnaea, p. 3, Susquehanna River, Pennsylvania.

Uranidea quiescens DeKay 1842, New York Fauna: Fishes, p. 61, Lake Pleasant, Adirondack Region.

Cottus formosus Girard 1850, Monogr. Cotti., in Smiths. Contrib. III, p. 58, off Oswego, Lake Ontario, in stomach of *Lota*.

Cottus gobioides Girard 1850, Proc. Am. Assoc. Advanc. Sci., II, p. 411, Lamville River, Johnson, Vt.

Cottus boleooides Girard 1850, loc. cit., p. 411, Windsor, Vt.

Cottus franklini Agassiz 1850, Lake Superior, p. 303, north and east shores of Lake Superior.

Cottus copei Abbott 1860, Proc. Acad. Nat. Sci. Philadelphia, XII, p. 326, probably New Jersey.

Uranidea spilota Cope 1865, Proc. Acad. Nat. Sci. Philadelphia, p. 182, Grand Rapids, Mich.

Uranidea hoyi Putnam 1876, in Nelson, Bull. Ill. Lab. Nat. Hist., Vol. I, No. 1, p. 41, Lake Michigan, in deep water.

Cottus gracilis cayuga Meek 1888, Ann. New York Acad. Sci., IV, p. 315, Cayuga Lake, New York.

Cottus philonips Eigenmann and Eigenmann 1892, Am. Nat., XXVI, p. 963, Kicking Horse River, Field, British Columbia.

Cottus chamberlaini Evermann and Goldsborough 1906, Bull. U.S. Bur. Fish. XXVI, p. 308, fig. 66, Loring, Alaska.

Cottus kaganowskii Berg 1932, Copeia, No. 1, p. 17, fig. 1, 2, Anadyr River, U.S.S.R.

Description. D_1 7-9 (10); D_2 15-19; C 6-10 + 12 + 5-9; A 10-12 (13); P 12-15; V I, 3-4; Vert. 20-24; L.L. 18-22 (12-25). Total length up to 120 mm. Head and mouth small, head 3.0-3.9 times in standard length. Posterior nostril not tubular. Caudal peduncle deep, 3.5-4.2 (rarely 3.2-4.4) times in head, comprising .071-.089 of standard length. No teeth on palatine bones. Preopercular spines 1-3. Weak prickles found only immediately behind the pectoral fin. Prickles with small oval base and

sharp spine (Figure 3). Usually only one spine on the first dorsal fin basal. In some specimens the last two dorsal rays are on separate basals; in others the last two rays are on one basal (as in all other B.C. species); in some specimens the last two anal rays are on separate basals; in other specimens the last two anal rays are on one basal (as in all B.C. species) (see section on "Geographic Variation"). Operculo-mandibular pores 10-10 (rarely 11-11; two pores on tip of chin, one on either side of the midline; postmaxillary pore single); infra-orbital pores usually nine. Lateral line always incomplete, ending below the middle of the second dorsal fin. Anal papilla of adult male a flat "V," twice as long as the female's small round protrusion.

Highly mottled grey-yellow coloration. Often orange flashes on the lower flanks and under pectorals. Light fine speckling on chin. Usually three dark bars under the second dorsal, sometimes two. Spinous dorsal of male in spawning season black with broad orange edge. Male generally dark in spawning season.

Distribution. Eastern Siberia and Alaska east through Yukon, Northwest Territories, and the Prairie Provinces, the Quebec-Labrador peninsula to New Brunswick, south to Virginia, Iowa, and Minnesota in the east, and Washington and Montana in the west. On the Pacific Coast of North America it occurs from the Susitna River and Cook Inlet drainages south as far as the Taku and Stikine rivers but has not been taken in the Skeena nor in any coastal areas farther south with the exception of one puzzling record from the Martin River at Ocean Falls. It has been found in the Fraser system only in tributaries above the Fraser Canyon, and in the upper Columbia system. It is widespread in the Peace, Liard, and Yukon drainages.

Geographic Variation. Early examination of variation in *Cottus cognatus* in British Columbia suggested a morphological separation between populations from northern and southern regions, based on the number of pelvic fin rays (Lindsey, 1956). Subsequent study showed that the character of a single or "unbranched" last anal fin ray demonstrated an even sharper geographic break. In seeking the reason behind this break, it has been possible to examine extensive new material from the Northwest Territories collected by the Arctic Unit of the Fisheries Research Board of Canada, as well as collections from elsewhere kindly loaned by the Royal Ontario Museum and the University of Alberta.

Data from this material are summarized in Table 4, and shown on Figure 5. Fish with "unbranched anal rays" are those in which the posterior ray of the anal fin arose from a separate basal element rather than from one also shared by the next most anterior ray. "Three pelvic rays" refers to fins in which not even a vestige of a fourth soft ray was visible. This character was usually examined in both fins of each fish, so that the percentage calculated for each population is based on fins rather than on individuals. Where several samples were available from one drainage system and did not display marked variability, they have been combined in Table 4. The number of such different samples contributing to each percentage is indicated in Table 4; their localities are in each case enclosed within a circle or oval in Figure 5.

TABLE 4

Morphological Variation in *Cottus cognatus*

(For explanation see Figure 5 and text.)

—	No. of Local- ities	Last Anal Ray			Pelvic Ray		
		Single	Double	Single %	3	4	$\frac{3}{c/c}$
Yukon R., Alaska, Y.T., B.C. . . .	15	6	111	5	14	220	6
Cook Inlet drainages, Alaska	7	0	34	0	7	59	11
Copper River, Alaska	5	1	26	4	2	53	4
Alsek River, Y.T.	3	3	33	8	7	64	10
Chilkat River, B.C.	2	0	22	0	11	32	26
Taku River, Alaska, B.C.	2	0	10	0	2	14	12
Stikine River, B.C.	2	0	12	0	0	20	0
Martin R., Ocean Falls, B.C.	1	0	10	0	3	11	21
Liard R., B.C., Y.T.	5	0	35	0	5	61	8
Peace R., downstream	10	4	65	6	12	128	9
Peace R. below canyon, B.C.	7	12	58	17	23	106	18
Peace R. above canyon, B.C.	6	10	17	37	10	40	20
Fraser R., B.C.	11	28	69	29	101	96	51
Columbia R., B.C.	14	42	87	33	69	119	37
Great Slave L., N.W.T.	2	6	19	24	26	26	50
Clinton-Colden L., N.W.T.	2	0	32	0	39	35	53
Lac la Martre, N.W.T.	1	0	7	0	5	9	36
Beaverlodge L., N.W.T.	1	0	32	0	21	43	33
Great Bear L., N.W.T.	3	0	24	0	10	36	22
Coppermine R., N.W.T.	5	2	78	2	61	98	38
Burnside R., N.W.T.	2	1	38	3	45	32	59
Ellice R., N.W.T.	1	0	18	0	10	26	28
Beechey L., Back R., N.W.T.	1	0	20	0	17	23	42
Macdougall L., Back R., N.W.T.	3	0	3	0	3	3	50
Armit L., N.W.T.	1	0	21	0	21	21	50
Dubawnt L., N.W.T.	1	6	14	30	32	8	80
Beverly L., N.W.T.	1	8	11	42	23	15	60
Whitefish L., N.W.T.	1	16	4	80	37	3	92
Angikuni L., N.W.T.	1	10	10	50	30	10	75
Maze L., N.W.T.	1	17	4	85	42	0	100
Maguse L., N.W.T.	1	5	5	50	16	4	80
Hyde L., N.W.T.	1	1	2	33	6	4	60
Weir R., Man.	1	8	13	38	32	10	76
God's L., Man.	1	11	9	55	25	15	62
Severn R., Man.	3	3	4	43	10	4	71
Heming L., Nelson R., Man.	2	28	12	70	53	27	66
Steepprock L., Man.	1	12	8	60	31	9	77
Clear L., Churchill R., Alberta	1	7	2	78	18	0	100
Lake Athabasca, Sask.	1	4	0	100	8	0	100
Long L., Geraldton, Ont.	2	13	14	48	41	13	76
Lake Nipigon, Ont.	4	5	3	62	11	5	69
Pine R., Mich.	1	4	1	80	5	5	50
Lake Ontario, Ont.	1	7	4	64	20	2	91
St. Lawrence R., Quebec, Que.	3	21	6	78	53	1	98
St. Andrews stream, N.B.	1	5	0	100	10	0	100
Hudson R., N.Y.	3	6	2	75	16	0	100
Chimo, Ungava, Que.	3	10	7	59	29	5	85
George R., Ungava, Que.	1	4	2	67	12	0	100

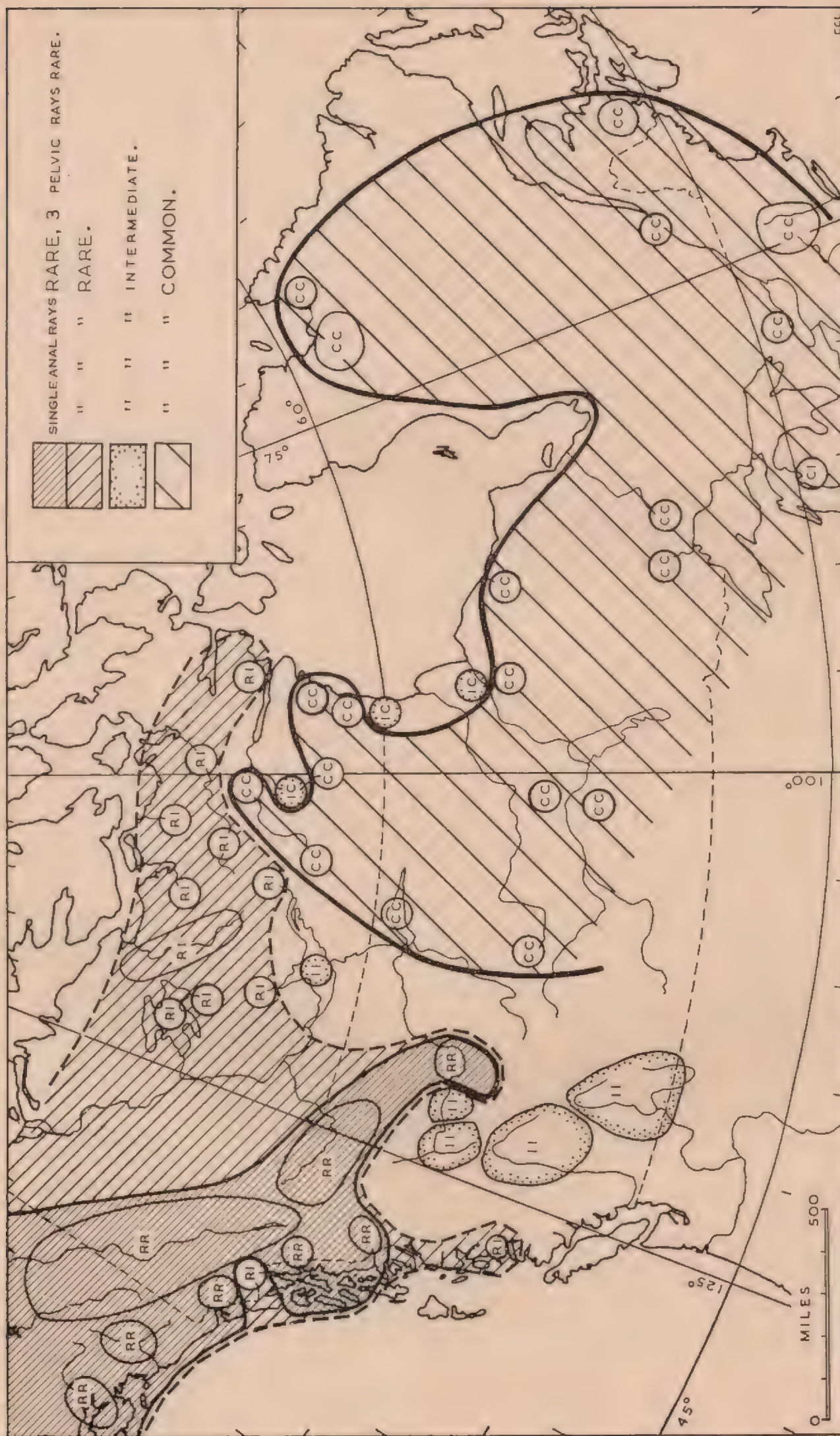


FIGURE 5. Distribution of morphological characters in *Cottus cognatus*. Each circle or oval encloses collections from an area listed in Table 4. The two letters within each area refer respectively to branching of the last anal fin ray and to the absence of a fourth pelvic ray. Each character is classed as R (rare), I (intermediate), C (common) according to the following scale—Percentage with unbranched last anal ray: 0-10 (R), 11-40 (I), 41-100 (C). Percentage with only 3 pelvic rays: 0-12 (R), 13-59 (I), 60-100 (C).

Of the two characters shown, percentage of unbranched last anal rays gives the most consistent picture and is evidently subject to little variation between closely adjoining areas. Unbranched anal rays are consistently rare in populations from Yukon River, Pacific coastal drainages, lower Mackenzie River, and northern Northwest Territories. They are consistently common in most of the rest of Canada and northeastern United States, with the exception of a band of intermediacy occupying southern and central interior British Columbia and Great Slave Lake. Differences are presumably genetically rather than environmentally determined, because low percentages occur in Pacific coastal areas with mild climate as well as in the Barren Grounds north of the Arctic Circle. Conversely, climate in the latter area, where unbranched rays are very rare, is comparable to climate in Ungava, where unbranched rays are common.

The percentage of pelvic fins with only three rays presents a picture in broad agreement with the foregoing, although the northern Northwest Territories tend to have intermediate rather than low percentages. There is, however, occasional erratic variability, suggesting that in this character local populations may develop independent divergence. For example, *C. cognatus* in the high tundra headwaters of the Chilkat system in northwestern British Columbia forms a pocket with 26 per cent pelvic fins having only three rays, although surrounded by drainages in which this character occurs in less than 12 per cent of fins. Other examples may be found of local irregularities, which may be due to genetic divergence (perhaps random or perhaps produced by selective pressures of a specialized environment) or else to direct phenotypic modification. Nevertheless, the broad geographic picture of low percentages in the northwest and high percentages in the southeast cannot be attributed to environmental influence, because character differences cut across climatic differences.

Variability in *C. cognatus* may be interpreted in terms of postglacial redispersal from two Pleistocene refuges, one in unglaciated regions of the Yukon River or arctic slope of Alaska, and one south of the ice-sheet and east of the Continental Divide. In Figure 5 a heavy line is drawn around populations in which both characters are "common" (as defined in the caption). The enclosed area has probably been populated by fish moving north from the Mississippi, Great Lakes, or Appalachian regions following the receding ice-sheet. This southern form has moved up both sides of Hudson Bay, as far as tributaries to Chesterfield Inlet on the west, and into Lake Athabasca on the upper Mackenzie (which even now is connected to Hudson Bay drainages via Wollaston Lake).

The northwestern form, in which both characters are "rare", invaded successive coastal rivers south along the Pacific slope, and also moved eastward across northern Canada to occupy the lower Mackenzie, the shorter Arctic drainages east to Back River, and eventually the shores of Hudson Bay north of Chesterfield Inlet. As indicated by shaded areas in Figure 5, populations throughout the described area are northern with regard to the more stable character (unbranched anal rays), but east of Yukon Territory they are intermediate in the other character. Possibly the southern form broke through into the upper Mackenzie and spread genes downstream to mix with the northern form before the latter invaded the northeastern Arctic drainages. If so, the extreme rarity of unbranched anal

rays in the latter area is surprising. One is faced with the difficulty of explaining intermediacy in one character and not in the other. The two characters show no obvious correlation *within* populations.

A clearer case of probable hybridization between the two forms occurs in Great Slave Lake, where sculpins are intermediate, in both characters, between Lake Athabasca populations to the south and those of Mackenzie River tributaries to the north (Table 4). Similarly there is some suggestion of northern genes having extended down the west shore of Hudson Bay possibly as far south as the Nelson River mouth.

In the Peace River of British Columbia and Alberta, a distinct cline occurs in both characters. Peace River collections have been classed according to their geographic relation to the Peace River Canyon near Hudson Hope, about 100 miles west of the British Columbia-Alberta boundary. Table 4 shows separately those populations from above the canyon, those from the river and its tributaries in British Columbia which are less than 120 miles by water below the canyon, and those from farther downstream in British Columbia or Alberta. In both characters the downstream populations resemble the Liard and Yukon river form, the upstream populations are closer to those from the Fraser and Columbia systems, and the intervening populations are intermediate.

The Peace River canyon has acted as a barrier to upstream spread of at least five species of fish (*Cottus ricei*, *Percopsis omiscomaycush*, *Stizostedion vitreum*, *Esox lucius*, and *Platygobio gracilis*) and presumably restricts or prevents upstream gene-flow in *Cottus cognatus*. On the other hand, the upper Peace River has evidently recently received elements from the Fraser River fish fauna (*Cottus asper*, *Catostomus macrocheilus*, *Richardsonius balteatus*, *Ptychocheilus oregonense*, and *Mylocheilus caurinum*), and *C. cognatus* may have reached the upper Peace in a like manner from the south. The present cline may therefore be the result of a oneway gene flow between upstream populations derived from southern British Columbia and downstream populations which entered from the Yukon River via the lower Mackenzie. However, the possibility of occasional, or past, upstream movement of sculpins cannot be ruled out. (*Thymallus arcticus* and *Catostomus commersoni* have both surmounted or by-passed the Peace canyon at some time (Lindsey 1956)). The upper Peace populations of *C. cognatus*, although comparatively high in percentage of unbranched anal rays, are actually closer in pelvic ray count to the populations immediately downstream than to those of the Fraser River fish. If "leakage" of genes has occurred in an upstream direction, it has produced a condition comparable to that in the northern Northwest Territories, with complete dominance in one character but intermediacy in the other.

The origin of *C. cognatus* in the Fraser and Columbia systems can now be considered. That these areas have been populated entirely from the Yukon system since the last glaciation is improbable from the known distribution of other species and from the morphological divergence discussed. On the other hand, Columbia, Fraser, and upper Peace populations are intermediate in both characters, and so do not seem to have been derived purely from the southeastern form. There remain the possibilities that all southern British Columbia has been populated from a hybrid

source which arose since glaciation, or, alternatively, that the area contains fish originating from a third glacial refuge south of the ice-sheet and west of the Continental Divide.

The first possibility meets with difficulties in reconstructing a sequence of postglacial water courses which would allow genes from Alaska and from the southeast to meet and then move successively into each of the major watersheds of southern British Columbia. The present cline in the Peace River system would be difficult to explain in these terms, although some sequences of watershed diversions can be postulated that cannot at the moment be disproved.

Alternatively, the hypothesis of a third glacial refuge in the Columbia basin is in keeping with the distribution of several other species (e.g. *Cottus hubbsi*, *Cottus rhotheus*, *Catostomus columbianus*, *Rhinichthys falcatus*) now restricted to the Pacific slope and occurring nowhere south of the Columbia River. The apparent intermediacy of the southern British Columbia form might be due to its origin, during the *previous* interglacial period, by hybridization of northwestern and southeastern forms. However, the intermediacy may be illusory; it is based on only two characters, which may have developed independently during isolation. If so, other distinctive characters unique to populations in this area may be expected.

The origin of the southern British Columbian form cannot be decided without further study. The evidence available does demonstrate that *Cottus cognatus* has entered the province from at least two sources. The northwestern coastal drainages, the Yukon and the Liard systems, contain "pure" populations derived from an Alaskan or Yukon Territory glacial refuge. The southern interior drainages are derived either from hybrids between the former and a southeastern form, or perhaps from an independent glacial refuge in the Columbia River. Finally, the isolated coastal population at Ocean Falls, which is separated from more northerly coastal populations by the apparently uninhabited Skeena and Nass drainage basins, has perhaps been formed by headwater capture from the Fraser River system. The occurrence of pockets along the irregular British Columbia coast containing residual freshwater populations which escaped the last glaciation is unlikely but not impossible.

The case for recognition of subspecies is marginal. On the basis of the two characters discussed, it is possible to assign the great majority of *populations*, but not of *individuals*, to either northern or southern origin (omitting southern British Columbia for the moment). Each of the heavy outlines on Figure 5 probably encloses populations of common origin, having relatively homogeneous characters which differ distinctly from populations within the other outline. On this basis two subspecies could be recognized, *Cottus cognatus cognatus* Richardson (first named from Great Bear Lake), and *Cottus cognatus gracilis* Heckel (first named from New York). The former populations have fewer than 10 per cent of individuals with single last anal rays, and fewer than 60 per cent of pelvic fins with only three rays. The latter populations have over 40 per cent and over 60 per cent for these two characters, respectively. About 80 per cent of the areas listed in Table 4 fall definitely into one or other of these categories.

British Columbia populations from the Peace, Fraser, and Columbia systems are intermediate according to the foregoing classification. If they are truly of hybrid origin, then in a system of formal subspecific nomen-

clature they would have to be labelled as intergrades. If, on the other hand, further evidence (such as discovery of characteristics exclusive to these populations) strengthens the view that they represent descendants from a third glacial refuge, then they may warrant a third subspecific name. In this case the name *Cottus cognatus philonips* Eigenmann and Eigenmann would be available, as *C. philonips*, here synonymized with *C. cognatus* for the reasons following, was named from southeastern British Columbia.

Status of *Cottus philonips*

In 1892 Eigenmann secured 17 specimens of *Cottus* in the snow waters of the Kicking Horse River (Columbia system) in southeastern British Columbia. These specimens were named as a new species, *Cottus philonips*, by Eigenmann and his wife in the same year. With further knowledge of the variability and distribution of *Cottus cognatus*, it appears that *philonips* is a synonym of *cognatus*. In Table 5 below are compared *philonips* and *cognatus*; the description of *philonips* was obtained from the original description of Eigenmann and Eigenmann (1892) and from Jordan and Evermann (1898).

TABLE 5

Comparison of *Cottus cognatus* and *Cottus philonips*

—	<i>Cottus philonips</i>	<i>Cottus cognatus</i>
Standard length/head length.....	3.8	3.0-3.9
Dorsal fin count.....	8-9; 16-18	7-9; 15-19
Anal rays.....	11-13	10-13
Palatine teeth.....	absent	absent
Pelvic rays.....	4	3-4

Four topotypic specimens of *Cottus philonips* (Royal Ontario Museum No. 18184) were examined. These had one preopercular spine (4 specimens); no palatine teeth (4); 8 (2) or 9 (2) dorsal spines; 16 (2), 17 (1), or 18 (1) dorsal rays; 11 (2) or 13 (2) anal rays; 3 pelvic fin rays (4); 13 (1) or 14 (3) pectoral rays; 10-10 preoperculo-mandibular pores; incomplete lateral lines; a few weak prickles behind the pectoral fin. The anal rays were unbranched in three, branched in one. Colour was in no way different from *Cottus cognatus*. Since the type description and topotypic specimens of *philonips* present no characters of specific significance differentiating them from *cognatus*, we consider *Cottus philonips* a synonym of *Cottus cognatus*.

Status of *Cottus kaganowskii*

Examination of the description and specimens of *Cottus kaganowskii* of Russia leads N. J. Wilimovsky and C. R. Robins (in Walters, 1955) to believe it to be a synonym of *C. cognatus*. Examination of specimens of *C. kaganowskii* from Siberia in the collections of the University of Michigan Museum of Zoology confirms this opinion. It may be noted here that the figures of *Cottus kaganowskii* and *Cottus nasalis* in Berg (1949) are reversed.

Status of *Cottus chamberlaini*

The original description of *Cottus chamberlaini* (Evermann and Goldsborough 1907) presents few features by which it can be distinguished from *Cottus cognatus*. This similarity was noted by Robins and Miller (1957). The description did differ from *cognatus* in (a) the presence of a tubular posterior nostril, (b) a complete or nearly complete lateral line (both of these features characteristic of *C. aleuticus*). William R. Taylor kindly examined the holotype (U.S. National Museum No. 57823) of *Cottus chamberlaini* for us. He found that the posterior nostril "barely projects and is approximately $\frac{1}{4}$ as long as the anterior nostril"—so that it can hardly be considered tubular, and that "the lateral line ends below the eighth dorsal spine, with 9 pores on the left side and 10 on the right, behind the gill opening"—so that the lateral line must be regarded as incomplete. (The specimen is of sufficient size to have the lateral line fully developed.) Further, there was no median pore on the tip of the chin, thereby resembling *cognatus* and differing from *aleuticus*. These observations indicate that the original description is inaccurate, and the type shows no characters by which it may be separated from *Cottus cognatus*. Hence we conclude that *C. chamberlaini* is a synonym of *C. cognatus*.

Affinities. Several authors, from the original describer, Richardson, to Wynne-Edwards (1952) have suggested that *Cottus cognatus* differs only slightly from the palearctic *Cottus gobio*. Indeed, *cognatus* means "related" (to *C. gobio*). However, examination of specimens of *C. gobio* reveals the following trenchant characters by which it may be distinguished: one pore on the tip of the chin, lateral line typically complete, and decurved under the first dorsal fin; maxillary little exposed, covered by protrusion of the premaxillaries. We therefore do not consider *C. gobio* close to *C. cognatus*.

Cottus cognatus should be included in the *bairdii-hubbsi-gulosus* species complex. These species are very closely related, and it is sometimes difficult to separate them. Indeed it is this species group which has contributed most to taxonomic confusion in the genus *Cottus*.

Cottus hubbsi Bailey and Dimick 1949

Columbia sculpin

Cottus hubbsi Bailey and Dimick, Occ. Pap. Mus. Zool., Univ. Michigan No. 513, p. 1, Entiat River, Chelan County, Washington.

Description. D_1 7-8; D_2 16-18; C 6-9+12+5-8; A (11) 12-14; P (13) 14-16; V I, 4; Vert. 21-23; L. L. 28-36 (23-38). Total length to 122 mm. Head and mouth of medium length, head entering standard length 2.9-3.2 times. Posterior nostril semitubular. Caudal peduncle of medium depth, entering head 3.7-4.6 times, comprising .072-.085 of standard length. Strong palatine teeth separated by tissue from the vomerine teeth. Three preopercular spines. Prickles usually restricted to patch behind pectoral but sometimes extending along back. Prickles with short sharp shaft on a relatively smooth oval or round base. One spine on the first dorsal fin basal. Preoperculo-mandibular pores 11-11 (two on the tip of the chin, one on either side of the midline; postmaxillary pore double); infraorbital pores 9. Lateral line usually incomplete, missing on all or part of the caudal peduncle, with about 23-24 pores. Genital papilla longer in adult male.

Usually three dark bands under the second dorsal. Chin usually lightly and evenly covered with fine speckles. Dark spot in the anterior and posterior parts of the first dorsal of both sexes; these spots in the breeding male fuse to form a median band.

Distribution. *Cottus hubbsi* is presently known only from the Columbia drainages of Idaho, Washington, and British Columbia. In British Columbia it is known only from the Similkameen and its tributaries, and the Kettle River. This species evidently survived glaciation south of the ice-sheet.

Affinities. As noted by Robins and Miller (1957) *Cottus gulosus* (not of Schultz) is very closely allied to *Cottus hubbsi*. *Cottus hubbsi* is also allied to the *bairdii-cognatus* complex, as noted under *Cottus cognatus*.

Cottus sp.

shorthead sculpin

Description. D_1 8-9; D_2 17-19; C 7-9+12+7-8; A 12-14; P 13-15; V I, 4 (5); Vert. 22-23; L. L. 20-24. Total length to 105 mm. Body stout. Head short, round from above, 3.1-3.7 times in standard length. Posterior nostril semitubular. Caudal peduncle depth medium, 3.2-3.9 times in head length, .078-.098 of standard length. Preopercular spines 2, sometimes 3. Prickles in weak patch behind pectoral fin. Palatine teeth present but weak, separated from vomerine tooth patch. One spine on the first dorsal fin basal. Preoperculo-mandibular pores 10-10 (two pores on tip of chin, one on either side of midline; postmaxillary pore single); infraorbital pores 9. Papillae on top of head better developed than in other British Columbia species. Lateral line incomplete, extending two-thirds the length of the second dorsal fin, with 20-24 pores. Genital papilla of male well developed, a large flat "V".

Body colour a light brown-yellow with dark mottlings. Sides usually pale without bars, sometimes three dark mottled bars under second dorsal. Post-interorbital region dark. Chin lightly and evenly speckled. First dorsal fin dark anteriorly and posteriorly between the rays, sometimes with median band.

Status, Affinities, and Distribution. The exact status of this species is uncertain at the moment, although it should be aligned with the *hubbsi-bairdii-cognatus* group. It is under study by Dr. R. M. Bailey of the University of Michigan, who has also found it in northeastern Oregon, Idaho, and eastern Washington. In British Columbia it has been found only in the Flathead River in southeastern British Columbia. It probably survived glaciation south of the ice-sheet. It may represent a new species.

Cottus rhotheus (Rosa Smith) 1882

torrent sculpin

Uranidea rhothea Rosa Smith (Mrs. Eigenmann) 1882, Proc. U.S. Nat. Mus. 5, p. 347, Spokane Falls, Washington.

Description. D_1 7-9, D_2 15-17; C 6-9+12+5-7; A 11-13; P 15-17; V I, 4; Vert. 21-22; L. L. 29-35. Total length to 160 mm. Head large, 2.65-3.0 times in standard length. Mouth large (see Northcote 1954 for comparison with *Cottus asper*). Posterior nostril semitubular. Caudal peduncle narrow, depth entering head length 4.8-6.4 times, comprising

.057-.068 of standard length. Underside of head wrinkled. Strong teeth on palatine bones; palatine tooth patch long and in contact with vomerine tooth patch, unlike any other British Columbia species (Northcote, 1950). Three preopercular spines. Well-developed prickles usually on back and sides, often extending onto caudal peduncle but occasionally restricted to an area immediately behind the pectoral fin (see Bailey and Dimick, 1949). Prickles with a sharp spine and a large oval base serrated on the side opposite the spine (Figure 3). Usually one spine on the first dorsal fin basal. Operculo-mandibular pores 11-11 (two pores on the tip of the chin, one on either side of the midline; postmaxillary pore double); infraorbital pores 9. Lateral line usually complete, often extending onto caudal fin.

Two dark bars, sharply outlined and angled forward, under the second dorsal fin; occasionally a small bar between them. Bars on pectoral fin usually poorly defined, speckled. Chin strongly mottled with coarse speckles (unlike other B.C. species). Edge of spinous dorsal in spawning males thickened and orange coloured.

Distribution. The torrent sculpin is found in Columbia drainages of Washington, Idaho, and Oregon and south from Puget Sound drainages of Washington to the Nehalem River on the Oregon Coast. In British Columbia it is known from the North Thompson River (Fraser drainage) and in most of the Columbia River system. For further details of British Columbia distribution, see Carl, Clemens, and Lindsey (1959). This species doubtless survived glaciation south of the ice-sheet in the Columbia drainage.

Geographic Variation. Bailey and Dimick (1949) found that *Cottus rhotheus* exhibits considerable geographic variation. Specimens from coastal Washington and Oregon were found to have a somewhat shorter head, a less complete lateral line, and the prickles on the body much reduced or absent compared to inland specimens. The latter finding is similar to the condition found in *Cottus asper*. Northcote (1950) found that the difference in dorsal rays between both Idaho and Columbia River-Arrow Lakes was statistically significant. A significant increase in caudal vertebrae between Oregon and British Columbia was also discovered.

Affinities. As noted by Bailey and Dimick (1949), *Cottus rhotheus* is apparently most intimately related to *Cottus carolinæ* (Gill) of the southeastern United States. These species share a large head, slender caudal peduncle, well-developed preopercular armature, similar colouring of pectoral fins, a mottled chin, and two bars under the second dorsal fin. *Cottus rhotheus* also shares a few features with *Cottus ricei*—similar prickles, wrinkled chin, slender caudal peduncle, and semitubular nostrils.

***Cottus ricei* (Nelson) 1876**

spoonhead sculpin

Cottopsis ricei Nelson 1876, Bull. Ill. Lab. Nat. Hist., I, p. 40, Lake Michigan off Evanston, Illinois.

Uranidea pollicaris Jordan and Gilbert 1882, Proc. U.S. Mus., V, p. 222, Lake Michigan off Racine, Wisconsin.

Cottus onychus Eigenmann and Eigenmann 1892, American Nat. XXVI, p. 963, Bow River at Calgary, Alberta.

Description. D₁ 7-10; D₂ 16-18; C 6-7+12+7-10; A 12-13; P 14-16; V I, 4; Vert. 23-24; L. L. 33-36. Total length to 50 mm. Head and mouth small, head about 2.9-3.7 times in standard length. Little of maxilla

exposed compared to other British Columbia sculpins. The maxilla terminating anterior to a vertical through the front of the eye. Preorbitals wide, extending almost as far forward as tip of snout behind lip, giving the outline of the snout behind the lip a "W" shape from above (Figure 1A). (In other British Columbia sculpins the snout recedes from the tip giving it a rounded or "^" shape.) Posterior nostril semitubular. Caudal peduncle narrow, 5-7 times in head, .045-.065 times in standard length. Underside of head wrinkled. No palatine teeth. Three, sometimes two or four, preopercular spines, the uppermost curved inward and resembling a bison's horn. (In other British Columbia sculpins it is shorter, almost straight and not curved inward.) Prickling highly variable; may extend over whole body, be reduced, or absent. Prickles with a sharp spine and a large oval base serrated on the side opposite the spine (Figure 3). One spine on the first dorsal fin basal. Preoperculo-mandibular pores large, 10-1-10 (one median pore on the tip of the chin; postmaxillary pore double); infraorbital pores 8. Lateral line usually complete, slightly decurved under the first dorsal fin, straight thereafter without deflection on the caudal peduncle.

Two to four dark bars under the second dorsal fin. First dorsal fin (at least in non-spawning specimens) without dark blotches, other than bands crossing fin rays.

Distribution. The spoonhead sculpin is found in the Great Lakes, Lake Nipigon, in James Bay tributaries, Bow and North Saskatchewan rivers of Alberta, Peace River, Lake Athabasca and Great Slave Lake, Muskwa River, Nueltin Lake, and in the main Mackenzie River to the delta. It is apparently absent from Alaska despite the report by Wynne-Edwards (1952). In British Columbia it has been found only in the lower portion of the Peace River and in Muskwa River (Liard-Mackenzie drainage). The spoonhead sculpin probably survived glaciation south of the ice-sheet in the mid-section of the continent.

Affinities. The spoonhead sculpin is the most distinctive member of its genus in North America. It appears to be closely related to none of the North American species, except perhaps *Cottus rhotheus* (as noted before). Two freshwater sculpins in northern Asia, *Cottus sibiricus* and *C. spinulosus*, appear, from the descriptions and illustrations in Berg (1949), to be quite intimately related to *C. ricei*. (The closeness of *sibiricus* to *ricei* has already been noticed by Wynne-Edwards, 1952.)

Examination of central European specimens of the palearctic *Cottus gobio* also suggests relationship to *C. ricei*. These species share one pore on the tip of the chin, an incurved preopercular spine, a complete lateral line which tends to be decurved under the first dorsal fin and to proceed thence straight to the base of the caudal fin without a deflection on the caudal peduncle, lack of palatine teeth, four pelvic rays, a maxillary little exposed and well covered by the protuberant preorbital bone. *Cottus ricei* may be distinguished from *C. gobio* by its slimmer caudal peduncle and usually more extensive prickling.

SUMMARY

Descriptions of the characters and geographic variation of the freshwater sculpins of British Columbia, *Cottus asper*, *C. aleuticus*, *C. cognatus*, *C. hubbsi*, *C. sp.*, *C. rhotheus*, and *C. ricei* are presented. Characters, counts,

and proportions are given in a consistent format. New characters, the shape of prickles, and the number of spines on the first dorsal basal were found to be of significance.

Synonymies are presented for the genus *Cottus* and each of the British Columbia species. *Cottus chamberlaini*, *C. philonips*, and *C. kaganowskii* are synonymized with *Cottus cognatus*.

Coastal specimens of *Cottus asper* were found to differ significantly from inland specimens in prickling, dorsal and pectoral rays, and caudal vertebrae.

Intraspecific variation was examined in 148 collections of *C. cognatus* from northern North America. Evidence is presented of survival in two or possibly three glacial refuges, one northwest of, and one or two south of the Pleistocene ice-sheet.

The relationships of British Columbia freshwater sculpins to one another and to some extralimital species are discussed.

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APPENDIX

TABLE 6

Number of Pores on the Tip of the Chin

Species	Number of Specimens with:	
	One Pore	Two Pores
<i>asper</i>	400	5
<i>aleuticus</i>	135	2
<i>princeps</i>	40	—
<i>gobio</i>	20	—
<i>sp.</i>	—	20
<i>hubbsi</i>	—	35
<i>cognatus</i>	1	462
<i>rhotheus</i>	—	33
<i>ricei</i>	21	—

TABLE 7

Number of Spines on the First Basal of the Spinous Dorsal Fin

Species	Number of Specimens with:	
	One Spine	Two Spines
<i>asper</i>	3	82
<i>aleuticus</i>	—	48
<i>sp.</i>	5	—
<i>hubbsi</i>	39	1
<i>cognatus</i>	46	5
<i>b. bairdii</i>	4	1
<i>rhotheus</i>	22	2
<i>carolinae</i>	7	2
<i>ricei</i>	12	2

TABLE 8

Number of Dorsal Basals (Under and Between First and Second Dorsal)

Species	Number of Specimens with Number of Basals								
	23	24	25	26	27	28	29	30	31
<i>asper</i>	—	—	—	—	2	20	43	17	1
<i>aleuticus</i>	—	—	—	9	21	8	—	—	—
<i>princeps</i>	—	—	—	—	1	3	2	—	—
<i>sp.</i>	—	—	1	1	2	—	—	—	—
<i>hubbsi</i>	—	4	26	10	—	—	—	—	—
<i>cognatus</i>	1	6	21	22	1	1	—	—	—
<i>b. bairdii</i>	—	—	2	—	—	—	—	—	—
<i>rhotheus</i>	—	17	7	1	—	—	—	—	—
<i>carolinae</i>	—	1	3	1	—	—	—	—	—

TABLE 9

Number of Minor Caudal Fin Rays

Species	Number of Specimens with:														
	Dorsal Minor Caudals						Ventral Minor Caudals								
	6	7	8	9	10	11	4	5	6	7	8	9	10	11	14
<i>asper</i>	—	1	4	32	10	3	—	1	2	3	19	19	8	1	1
<i>aleuticus</i>	1	5	8	4	—	—	—	—	3	8	6	1	—	—	—
<i>sp.</i>	—	1	2	2	—	—	—	—	—	3	2	—	—	—	—
<i>hubbsi</i>	3	8	5	1	—	—	—	3	7	6	1	—	—	—	—
<i>cognatus</i>	5	13	14	9	2	—	—	5	6	16	11	2	—	—	—
<i>b. bairdii</i>	4	—	—	—	—	—	1	2	1	—	—	—	—	—	—
<i>rhotheus</i>	4	8	4	1	—	—	—	5	11	1	—	—	—	—	—
<i>carolinae</i>	—	1	1	3	—	—	—	1	—	1	3	—	—	—	—
<i>ricei</i>	1	5	—	—	—	—	—	—	—	2	1	2	2	—	—

TABLE 10

Ranges of Caudal Vertebrae

Species	Number of Caudal Vertebrae									
	20	21	22	23	24	25	26	27	28	29
<i>asper</i>	—	—	—	—	x	x	x	x	x	x
<i>aleuticus</i>	—	—	—	—	x	x	x	x	—	—
<i>princeps</i>	—	—	—	—	x	x	x	—	—	—
<i>sp.</i>	—	—	x	x	—	—	—	—	—	—
<i>hubbsi</i>	—	x	x	x	—	—	—	—	—	—
<i>cognatus</i>	x	x	x	x	x	—	—	—	—	—
<i>b. bairdii</i>	x	x	—	—	—	—	—	—	—	—
<i>gulosus</i>	—	x	x	x	—	—	—	—	—	—
<i>marginatus</i>	—	x	x	x	—	—	—	—	—	—
<i>beldingii</i>	x	x	x	x	—	—	—	—	—	—
<i>tenuis</i>	—	—	—	x	x	x	—	—	—	—
<i>klamathensis</i>	x	x	x	x	—	—	—	—	—	—
<i>tubulatus</i>	x	x	x	x	—	—	—	—	—	—
<i>bendirei</i>	x	x	x	—	—	—	—	—	—	—
<i>rhotheus</i>	x	x	x	x	—	—	—	—	—	—
<i>carolinae</i>	—	x	x	—	—	—	—	—	—	—
<i>ricei</i>	—	—	—	x	x	x	—	—	—	—

The above table represents the range of caudal vertebrae counts for several species over their *whole* ranges. Counts are obtained from Schultz (1936), Hubbs and Schultz (1932), Robins and Miller (1957), Bailey and Dimick (1949), as well as from our own data. Only limited data are available for certain of the species with short ranges so that the above picture should not be regarded as final.

BIOLOGICAL INVESTIGATIONS AT ISACHSEN, ELLEF RINGNES ISLAND, N.W.T.

By S. D. MacDONALD

INTRODUCTION

This paper is based upon observations and specimens collected at Isachsen, Ellef Ringnes Island, N.W.T., during the field season of 1954. The expedition was sponsored by the National Museum of Canada. While in the field I was assisted by Mr. George Blanchard, also of the museum staff. We left Ottawa on April 11 and, after several short delays *en route*, reached Isachsen on April 23 where we remained until September 27.

Since no extensive biological work had previously been done at Isachsen, the purpose of our expedition was to collect specimens of all forms to supplement the national collections. The area studied was disappointingly barren. Wildlife was scarce and local in distribution. It was frequently possible to travel all day without seeing an animal of any kind. The weather was wet and windy, and cross-country travel was difficult during most of the year.

ACKNOWLEDGMENTS

The Canadian Department of Transport, Meteorological Division, and the United States Weather Bureau generously permitted us to use the Weather Station at Isachsen as a base camp. Special thanks are extended to Mr. J. Glenn Dyer, Chief of United States Arctic Operations Project, and to Mr. J. Courtney, Department of Transport, for providing 240 pounds of field rations and for making arrangements with the R.C.A.F. to have them dropped by parachute on the north side of the Island at Louise Fiord.

Transportation to Isachsen and return was provided by the Royal Canadian Air Force. The assistance and courtesies extended to us by their personnel were much appreciated.

GENERAL DESCRIPTION OF THE AREA

Ellef Ringnes Island has an area of approximately 5,000 square miles and is one of the northwestern Queen Elizabeth Islands. The locations studied were in the vicinity of Isachsen Weather Station at lat. $78^{\circ}47'7''$ N., long. $103^{\circ}31'40''$ W., along the coast of Deer Bay; and on the north coast in the Louise Fiord area. Together, they comprised an area of about 400 square miles.

This region is a low plain underlain by shale and some limestones of Lower and possibly Upper Cretaceous age (Heywood, 1957)¹. Its surface is highly dissected, and the network of streams that form a dendritic drainage pattern has eroded numerous steep-sided valleys.

My immediate impression of Isachsen was of a region of utter desolation. In late April when we arrived, the low-lying areas and gullies were filled with hard-packed snow. The ridges and hills were blown bare of snow

¹ W. W. Heywood (1957). Isachsen Area, Ellef Ringnes Island, District of Franklin, Northwest Territories. Geol. Surv. Canada, Pap. 56-8.

and finer soil particles, and the lack of vegetation was immediately apparent. Except for the occasional fox tracks, no evidence of animals was seen for several weeks.

During the winter, strong north or northwest winds sweep across Isachsen carrying with them snow, sand, and flakes of shale. These wind-borne abrasive particles soon wear away almost every piece of vegetation above the shelter of the snow, thus creating the characteristic impression of desolation.

Wind-blown snow, sand, shale, and bits of vegetation are piled in the gullies and lowlands in hard-packed, rippled drifts. Sastrugi are common everywhere, and the ridged surfaces they present are difficult to travel over, even on foot. Skis are practically useless because of the rough, glazed surfaces of the drifts. When the weather is very frosty, travel on foot is relatively easy, but when the snow softens with the onset of spring melting, snowshoes are necessary.

In 1954 the spring was cold, and melting proceeded very slowly. At this time the bare hilltops and snow-free slopes became very muddy. Melt-water collected in the snow-filled gullies and eventually began to run over the snow surface. The soil particles that had been mixed with the snow soon formed a layer over its surface and for a while hastened the melting process. In 1951, the station record showed 14 inches of wind-blown soil in drifts on the ice in Station Bay. Each winter's deposit of soil and vegetable fragments forms a layer along the slopes and makes a foundation over the rocks for an abundant growth of moss and other plants.

The streams, which carry large volumes of silt, have built up extensive deltas and muddy flats along the shores of the bays. The ice in Station Bay does not break up each year, and its almost continuous presence around Isachsen contributes to the low temperatures and foggy conditions that prevail during the summer.

Travel on foot overland during the period between spring thawing and autumn freeze-up is difficult. The hilltops become rather dry during the summer, but they are generally barren and unproductive. The wet lowland areas have pockets of vegetation, but in no place could the plant growth be considered lush.

MAMMALS

During the season at Isachsen we collected only four species of mammals. Nine species have been reported, but we recorded only seven.

Polar Bear *Thalarctos maritimus* (Phipps)

One was killed in the camp area in 1951 by Weather Station personnel. No others have been observed since that date, although we found old tracks on the sea-ice in Deer Bay while travelling around Isachsen Peninsula.

Arctic Weasel *Mustela erminea* Linnaeus

Tracks were seen commonly among the rocks and scree slopes of the ravines. Seven adults were collected, and all summer specimens were in good condition. The stomachs were empty in most specimens; remains of lemmings were found in three, and feathers of snow buntings in one. No young were collected or seen, and none of the females collected was lactating.

In late autumn several weasels came into the camp area to eat table scraps left by the dogs. These were obviously hungry and in very poor condition.

Arctic Fox *Alopex lagopus* (Linnaeus)

Tracks were common, but the animals themselves were seen only twice. The station dogs evidently are able to kill foxes during the winter when they come to feed in the camp area, and several mangled carcasses were found. Five adults were collected during the summer. Their stomachs were either empty or contained lemming remains. All of these had apparently been found dead. The large amount of white in the pelage suggested that they were autumn lemmings and not freshly caught summer specimens.

Arctic Wolf *Canis lupus* Linnaeus

The station journal indicates that wolves are uncommon at Isachsen; they usually appear in the area during the dark months, and in 1954 they killed and mauled several dogs.

Early in 1951 the station personnel reported that a calf muskox had been killed near the camp area by a single wolf and the station dogs. Mr. James Kitzinger told me that while the dogs were harassing two adult muskoxen with a yearling calf, a wolf appeared. It was attracted by this activity but kept in the background while the dogs held the muskoxen at bay. When one of the adults charged after a dog, the wolf ran at the calf, slashing open its flank as it passed. The calf was dead within minutes.

We saw no wolves or tracks during our stay at Isachsen, but in September we heard one howling in the hills north of the Station.

Ringed Seal *Phoca hispida* Schreber

Scarce. Six were seen during July in the small bays facing Prince Gustav Adolph Sea. "Seals" are mentioned only occasionally in the station journal.

Bearded Seal *Erignathus barbatus* (Erxleben)

Observed one during the summer in a shore lead at Deer Bay.

Collared Lemming *Dicrostonyx groenlandicus* (Traill)

No lemmings were seen during the season at Isachsen, nor were any occupied dens located. Station personnel told me that "lemmings were everywhere" in 1953 during the late summer. Dead lemmings in autumn and winter pelage were found in several of the storage buildings in the camp area and frequently on the hillsides in vegetated areas. Some of these had obviously been killed by a predator, but most of the carcasses gave no indication of the cause of death. In the case of all lemming carcasses found outside buildings, the pelage was in the transition stage from brown to white suggesting that the "crash" occurred in September, 1953.

Arctic Hare *Lepus arcticus* Ross

Not observed in 1954, but a few were noted by Heywood in 1953.

Peary Caribou *Rangifer pearyi* Allen

During the stay at Isachsen fifteen caribou were seen. These were all in the hilly region north of the station and in the vicinity of Louise Fiord. The scarcity of tracks and dropped antlers suggests that caribou are uncommon here, and the ones we observed were probably stragglers. All five specimens collected were very thin, even those taken in the summer. Before the new plant growth of the season appears they feed on lichens and willow (*Salix arctica*) twigs. During the summer *Saxifraga caespitosa* seems to be the favoured food plant and is taken in much greater quantities than willows.

White-faced Muskox *Ovibos moschatus* Lydekker

No muskoxen were seen on the Isachsen Peninsula in 1954. Bits of wool, droppings, and old tracks indicated that they appeared in the area occasionally. Heywood saw several in 1953, and in 1951 two adults with a yearling calf came into the camp area. While the dogs harassed the group, a wolf attacked and killed the calf.

BIRDS

As in the case of mammals, the number of birds recorded was equally small. In 1954 the spring was wet and cold, and less than five per cent of suitable habitat was snow-free when most of the birds arrived. Snow storms and strong winds were frequent during June and occasional during July. Consequently the number of breeding birds was small. Several specimens with incubation patches were collected, but no young birds were seen during the summer except one fledgling Snow Bunting.

Brant *Branta bernicla* (Linnaeus)

White-bellied Brant were observed frequently during the breeding season in 1954. All flocks were carefully checked, but the black-bellied form did not appear.

When the first Brant arrived, most of their habitat was still snow-covered. The first flock recorded was one of 14 birds feeding along the edge of a deep drift in a narrow valley where vegetation was exposed. These birds were paired, and the largest ovum in the one female collected was 40 mm.

One nest was found on June 29. It was located in a depression among small polygons and rocks on a grassy slope near the shore of Deer Bay. The nest, which had held four eggs, had been pillaged by some predator, possibly Glaucous Gulls, *Larus hyperboreus*. The shells were near the nest, and small blood vessels were apparent in the lining membranes of all of them.

A second nest was found on June 30. Located 30 yards from the shore, it was, like the first, well lined with grass, moss, and a large amount

of down. It was placed in a narrow fissure between two rock slabs which would have completely hidden the incubating bird. The nest was dishevelled as if vacated in a great hurry, and the five eggs were scattered about the rocks. One egg was broken; two were unfertile; in the others the development of the embryos had advanced to about the seven-day stage.

Flightless Brant were seen occasionally along the shore leads, but none were observed on any of the small ponds. The first flightless bird was found on June 30 in a flock of 28 others which showed no evidence of moulting. On July 4, in a flock of 13, three were flightless. When flushed from a shore lead, they flew out and landed on the bay ice. The flightless ones climbed out of the lead and ran over the ice to join them.

The last Brant were seen on July 28, also in a shore lead. All twelve birds were unable to fly. All birds collected had been feeding extensively on *Juncus biglumis*. No young were observed, and no migrating Brant were seen.

Old Squaw *Clangula hyemalis* (Linnaeus)

Occasional. During July several small groups appeared in the shore leads. Single males were first seen, and later they were joined by thirteen females. None of these birds were flightless, and no evidence of breeding was found.

King Eider *Somateria spectabilis* (Linnaeus)

Observed once during the season.

White Gyrfalcon *Falco rusticolus* (Linnaeus)

None were seen in 1954, but station personnel reported seeing "big white hawks roosting on the antenna masts last year." On June 30 I found the remains of a fully grown subadult Rock Ptarmigan, which had apparently been left by a Gyrfalcon in autumn 1953. The carcass had been completely plucked except the wings.

Rock Ptarmigan *Lagopus mutus* (Montin)

Seen occasionally from late May to early August. Breeds in the area, but no nests were found. They frequented the sheltered gullies with vegetated polygons and were seldom seen on the windy, rocky slopes.

The first bird, a male, was seen on May 30. It was flushed from its roosting bed in the snow on a ridge at about 250 feet and flew out of sight at this level over the sea. By June 7 females were beginning to show traces of summer plumage on the crown and back. On June 22 a female in complete summer plumage had a well-developed brood patch and a shelled egg in her oviduct. The male bird, still completely white, began a vigorous display when we entered his territory. It was similar to the courtship flight but seemed to be used as a distraction display. While the female skulked along in the depressions between the polygons, the male made short flights. Usually he flew off swiftly, very low, then suddenly soared to about 60 feet and at the peak of the rise gave a throaty "belching" note, which continued as he fluttered down with widely spread tail.

If approached, he would repeat the display and land still farther away; if not, he would fly silently back to his original perch on a mound, and try again. While on the ground he displayed his large scarlet combs and made short runs to attract attention to himself. I observed a husky pup, completely fooled by this bird's display, being enticed away from the territory time after time.

Summer plumage began to be apparent in males by June 30. At this time the winter plumage was so darkened by mud stains that it was effective as protective coloration.

One female was taken on June 30 and another on July 2. Both of these birds had evidently lost their eggs, because in each case the incubation patch was partly covered with new feathers. No young birds were seen, and the last adult was seen on August 9.

Knot *Calidris canutus* (Linnaeus)

Observed frequently during June and July. The first bird was observed on June 4 as it searched for food in the deposits of wind-blown soil and plant debris on the bay ice. Others were seen feeding along the muddy deltas and slopes. Birds collected at this time had a great deal of body fat. Stomach contents were composed wholly of plant material and seeds. One bird collected on June 11 had fed entirely on the new succulent leaves of *Ranunculus*. Insects were available at that time, and specimens collected later had fed on spiders and midge larvæ.

Courtship flight songs were heard the same day that the first birds were observed. The clear, musical, and melancholy notes were among the few bird sounds heard. Pairing took place as soon as the birds arrived, if not before, and within a week egg-laying was probably completed. Two females taken on June 11 had fully developed brood patches, and one had only one large (25 mm) ovum remaining.

During the summer no nests were found. The adults disappeared on July 11, and no young were seen in migration.

Baird's Sandpiper *Erolia bairdii* (Coues)

Thirty were observed between June 28 and July 6. Although very scarce, it probably breeds in the area. Courtship songs were heard occasionally, but no nests were found. One adult male and its mate with well-developed incubation patches were collected in late June. No young were seen, and it is likely that none survived the cold, wet weather.

Red Phalarope *Phalaropus fulicarius* (Linnaeus)

Observed only once. One adult male was collected at the edge of a tundra pond on June 24.

Long-tailed Jaeger *Stercorarius longicaudus* Vieillot

Long-tailed Jaegers appeared on June 4 and vanished one month later. They fed mostly along the beach, singly or in groups of six birds or less, where masses of crustaceans were washed ashore. The few birds which were seen inland gave no indication of nesting.

Glaucous Gull *Larus hyperboreus* Gunnerus

On June 4 a colony of five pairs was found already established on its nesting ledge on a south-facing cliff overlooking the sea. The cliff was estimated to be about 300 feet high, with the nest ledge about 100 feet below the summit. The cliff face above the nests was overhanging, and it was not possible to see into them.

Evidently this nest site had been used for a long time, and it was overgrown by a lush carpet of green grasses and arctic poppies. The birds vigorously defended the area until it was deserted on July 29 when only a single pair remained. No young were seen.

Snowy Owl *Nyctea nyctea* (Linnaeus)

None were seen in 1954. Station personnel reported seeing them the previous year. Pellets and feathers found on many mounds suggested that they had been present in fair numbers.

Snow Bunting *Plectrophenax nivalis* (Linnaeus)

Snow Buntings were seen more often than any other birds, but the breeding population was very small. The first bird was seen on April 29, but because of the cold weather no songs were heard until May 30. These first arrivals were all males, and at this time they actively defended territories on the rocky slopes. Full songs, given from perches and on the wing, were common on June 4 when the first females were seen. Two females were taken on June 21; each had a shelled egg in her oviduct. No nests could be found, and the last songs were heard on July 14.

The only juvenal bunting was observed on July 25. It was attended by both adults. Flocks of adults in heavy moult were noted on July 28, and after that date Snow Buntings were seldom seen. Flocks of migrating adults and young were seen in late August and early September. The last birds, a flock of 210 individuals, were seen on September 6.

PLANTS

A small plant collection of 113 numbers was made at Isachsen. These were determined by Dr. A. E. Porsild and are now in the National Herbarium of Canada. As an outline of the growth, abundance, and, in some cases, the first flowering date of the commonest plants, the following notes are given.

Plant growth was sparse and stunted in every area visited. Many of the plants were frozen in 1953 before the seeds matured and, in some forms, before all the buds had opened. Mosses and lichens made up the bulk of the vegetation, and apparently the soil was not suitable anywhere for a lush growth of vascular plants. The Poas, *Puccinellia angustata*, *Deschampsia pumila*, *Dupontia Fisheri*, *Phippsia algida*, *Luzula confusa*, *L. nivalis*, *Alopecurus alpinus*, and *Festuca brachyphylla*, were conspicuous in sparse stands or in isolated clumps.

Salix arctica was not common, and wherever it occurred the growth was very stunted. In almost every colony observed the thin branches had been severely pruned by lemmings. Not a single fruiting plant was found.

Ranunculus Sabinei was common everywhere. It was one of the first plants to flower (June 25) and continued flowering until killed by frost in late August. *Ranunculus sulphureus* was also abundant but was not so widespread as *R. Sabinei*.

Saxifraga oppositifolia with its familiar cushions of colourful flowers was noticeably absent from most of the hillsides. A few straggly clumps, many of them not producing blooms, were found among the rocks on sheltered slopes. The first blossoms were noted on June 20. *S. caespitosa*, *S. nivalis*, *S. tenuis*, and *S. rivularis* were all found frequently and in favourable locations flowered abundantly. *S. foliolosa* was not so conspicuous, though it was probably as abundant as the other saxifrages occurring at Isachsen.

Cerastium arcticum and *C. Regelii* were both common and were first seen in flower on June 26 along with *Potentilla* sp., *Cardamine bellidifolia*, *Draba oblongata*, and *D. subcapitata*. These species were all common.

MARINE INVERTEBRATES

When weather and ice conditions permitted, I was able to carry out limited dredging in Station Bay. The Weather Office provided the station with an excellent 12-foot dory, and this was used with a 2½ h.p. Johnson Seahorse outboard motor in all dredging operations. The dredge was small and light and was pulled by hand.

In early spring we cut through 108 inches of sea-ice to make vertical plankton drags, but very few specimens were taken in this way. During the summer it became increasingly apparent that ice conditions would not be favourable for extensive dredging. By June 28 the bay ice was still 85 inches thick. Leads were forming along the shores of all bays, and melt-water ponds standing on the ice had begun to cut channels along cracks, but no large leads were apparent.

The rush of muddy meltwater over the ice at the mouths of streams quickly made local openings. Most of the dredging was done in such locations and produced abundant specimens. Dredging was done in water varying in depth from 27 to 180 feet. In water shallower than 27 feet, sedentary animals were found only occasionally. Most of the work was done in 30 to 80 feet of water.

In every area worked, the bottom was of very soft silt. This presented a problem because the dredge soon became heavily loaded with bottom sediments. Thirty lots of specimens, representing most of the animal phyla from the Porifera through the Protochordata, are in the National Museum of Canada.

NOTES ON NEWFOUNDLAND BIRDS

By W. EARL GODFREY

INTRODUCTION

A National Museum of Canada ornithological expedition composed of Messrs. Henri Ouellet and Raymond McNeil, collected 817 bird specimens in Newfoundland in the period June 18 to September 8, 1959. From June 18 to July 30, Doyles was the centre of collecting activity, but specimens were taken also at Tompkins, Highlands, Cape Anguille, Stephenville Crossing, Cape Ray, and Table Mountain, all in the southwestern part of the island. Collecting began on August 4 in the southeastern part, on Green and Gull islands from August 4 to 7, and at Topsail Pond from August 11 to 21. The party then returned to Doyles to secure material in fresh autumn plumages. Collecting was resumed there on August 25 and continued to September 8.

This collection is supplemented in the National Museum of Canada by other Newfoundland material secured from various sources. Two notable collections, small but made up almost entirely of critical material, were secured by the National Museum's 1949 and 1950 mammalogical expeditions to Newfoundland, under Dr. A. W. Cameron, formerly Curator of Mammals at this institution.

The subjoined taxonomic notes are a by-product of routine identification of over one thousand Newfoundland bird specimens in the National Museum of Canada. Included also are distributional and breeding data secured by Messrs. Ouellet and McNeil in the course of their 1959 field work in Newfoundland. Because Peters and Burleigh (1951) have presented good accounts of the status of most bird species known to occur in Newfoundland, it would be redundant to prepare a complete annotated list of the species noted by our 1959 party. For that reason, only data that significantly supplement or add to information available in Peters and Burleigh (1951) are recorded here.

ACKNOWLEDGMENTS

For the loan of critical specimens of the Veery, in connection with a preliminary study of geographical variation in that species, the writer is indebted to Mrs. Gus Langelier and the Quebec Provincial Museum; to Dr. Herbert Friedmann and the United States National Museum; and to Mr. L. L. Snyder and the Royal Ontario Museum. Grateful acknowledgment is due Mr. P. W. P. Browne and Dr. Austin W. Cameron, who went to much trouble to secure Veeries from Lake St. John, Quebec, and the Magdalen Islands, respectively. Special thanks are due Mr. Leslie M. Tuck, who has in the past so frequently enriched the National Museum's collection by donating bird specimens documenting important Newfoundland records, and who in 1959 extended numerous courtesies and assistance to our field party.

TAXONOMIC NOTES

Lagopus lagopus alleni Stejneger. Willow Ptarmigan

Stejneger (1884) described this subspecies from Newfoundland, to which island it appears to be confined. It differs from *ungavus* in possessing relatively broad dusky shaft streaks and dusky mottling near the ends of the remiges.

Specimens examined (36): various parts of Newfoundland.

Lagopus mutus welchi Brewster. Rock Ptarmigan

This subspecies was recognized by Brewster (1885) and described from Newfoundland. Although only two specimens are available, they are more greyish (less brownish) than *rupestris*.

Specimens examined (2): Lewis Hills, 1 ad. ♂, 1 ad. ♀, August 19, 1915.

Sphyrapicus varius varius (Linnaeus). Yellow-bellied Sapsucker

Birds inhabiting Canada and northeastern United States have been considered separable from the nominate race by some authors. The trinomial *atrothorax* is available for these birds. The type of *Picus atrothorax* Lesson came from Newfoundland. The writer (Godfrey, 1949, pp. 22-23) agrees with Burleigh and Peters (1948) that the differences are not sufficiently constant to justify recognition as a separate subspecies.

Dendrocopos villosus terraenovae (Batchelder). Hairy Woodpecker

This extremely well-marked subspecies was described by Batchelder (1908) with type locality at Placentia, Newfoundland. It is readily separable from *septentrionalis* and *villosus* by a marked reduction in size and number of the white spots on the wing coverts, smaller white spots on the remiges, and less extensive white dorsal stripe. It is confined to Newfoundland.

Specimens examined (11): South Brook, 2 ad. ♂, 1 ad. ♀, 5 imm., June 28 - July 16, 1949; Harry's River, 1 imm. ♀, July 10, 1913; Doyles, 2 ad ♂, July 27 - 29, 1959.

Dendrocopos pubescens medianus (Swainson). Downy Woodpecker

Newfoundland Downy Woodpeckers have been separated by Oberholser (1914) as *D. p. microleucus*, the holotype of which came from Fox Island River. This separation has not been sustained by most authors. Although our material is badly worn, it is apparent that the white spots on the remiges and wing coverts are not consistently smaller or fewer than in *medianus*. I cannot be quite sure about the extent of the white dorsal stripe because of the poor condition of the specimens at hand. No differences are apparent in the barring of the rectrices, a highly variable character among individuals of most populations of the species. The black of the upper parts of the recently-taken Doyles series is noticeably darker than in the South Brook series taken ten years ago, this being due obviously to differences in 'museum age.'

Specimens examined (16): South Brook, 6 ad. ♂, 2 ad. ♀, 2 imm., June 27 - July 16, 1949; Doyles, 1 ad. ♂, 5 imm., June 24 - August 31, 1959.

Perisoreus canadensis sanfordi Oberholser. Gray Jay

This race, described by Oberholser (1914) with type locality at Fox Island River, Newfoundland, is a valid one. It is not confined to Newfoundland. Its characters and affinities will be discussed in a future paper planned by the writer.

Specimens examined (16): South Brook, 1 ad. ♂, 1 ad. ♀, 1 juv. ♀, July 7–9, 1949; Port Saunders, 1 ad. ♀, 1 juv. ♂, July 6, 1950; Salmonier, 1 ad. ♂, 1 ad. ♀, 1 juv. ♂, June 13, 1949; Deer Lake, 1 ad. ♂, August 3, 1949; Doyles, 1 ad. ♂, 2 ad. ♀, 1 post-juv., 3 juv., June 23 – September 7, 1959.

Parus atricapillus bartletti (Aldrich and Nutt). Black-capped Chickadee

Aldrich and Nutt (1939) described this well-marked subspecies, the type specimen of which came from Makinson's Grove, Avalon Peninsula, Newfoundland. As pointed out in the original description, it differs from the nominate race in possessing darker, more brownish upper parts, darker flanks and under tail coverts, and more restricted white edgings on the remiges. Although its describers were of the opinion that its characters are most pronounced in the eastern part of the island, our fresh-plumage specimens from the southeastern part (Doyles and St. Andrews) are as fully distinct as those from Topsail Pond on the Avalon Peninsula.

Specimens examined (19): Doyles (11), June 19 – August 15, 1959; St. Andrews (2), August 25, 1959; Topsail Pond (6), August 12–20, 1959.

Parus hudsonicus hudsonicus Forster. Boreal Chickadee

The Newfoundland population has been separated by Burleigh and Peters (1948) as *rabbittsi*, their type specimen from St. Andrews. The writer (Godfrey, 1951), in a study of variation in this species involving some 600 specimens from various parts of the range and including the paratypes of *rabbittsi*, concluded that Newfoundland birds are only intergrades between *littoralis* and *hudsonicus*. In fact, they are so extremely intermediate in both colour and size that it is a highly subjective matter to decide to which race they are more closely allied. The difficulties involved in attempting to separate this population may be seen by comparing the description of it by Peters and Burleigh (1948) with that by Todd (1950). The former paper describes it as paler than *hudsonicus*, the latter as darker!

Unfortunately, the A.O.U. Check-list of North American Birds (1957) has repeated the long-standing error of extending the range of *littoralis* north to the limit of the species range in northern Quebec. Birds inhabiting northern and middle Quebec have nothing to do with *littoralis* either in colour or size.

Troglodytes troglodytes hiemalis Vieillot. Winter Wren

Burleigh and Peters (1948) proposed the racial separation of Newfoundland birds as *T. t. aquilonaris* with type locality at Tompkins. Our material is poor, most of it in moult from juvenal to first basic plumage, and the writer is unable to express any definite opinion on the validity of this proposed new race. Possibly these immature birds average slightly less rufescent above than birds in comparable plumage from southern Quebec, but the difference shown is very slight.

Specimens examined (11): Millville, 6 imm., August 27, 1959; Doyles, 3 imm., July 24–September 4, 1959; South Brook, 1 ad. ♂, 1 juv., July 2–18, 1949.

Turdus migratorius nigrideus Aldrich and Nutt. American Robin

This heavily-pigmented race was separated by Aldrich and Nutt (1939) with Hodge Water, Newfoundland, the type locality. It has been readily accepted by taxonomists and justifiably so.

Like Burleigh and Peters (1948), I see no significant difference between material from eastern and western localities on the island, although eastern localities are not well represented in the collection.

Specimens examined (35): South Brook, 2 ad. ♂, 3 ad. ♀; Port Saunders, 1 ad. ♀, 1 juv.; Salmonier, 1 ad. ♂, 1 ad. ♀; Doyles, 3 ad. ♂, 5 ad. ♀, 9 juv.; Highlands, 3 ad. ♀, 1 juv.; Cape Anguille, 1 ad. ♀, 3 juv.; Topsail Pond, 1 juv.

Hylocichla guttata crymophila Burleigh and Peters. Hermit Thrush

This race, characterized by its describers, Burleigh and Peters (1948), as having darker upper parts and more greyish flanks than *faxoni*, appears to be fairly well marked. Although the upper parts of our five adults are badly worn and do not show the racial characters as well as birds in fresh plumage, the flanks are more greyish. Five juvenals average decidedly darker above than *faxoni*, and the first basic plumage being assumed by two others seems to conform with the original description of birds in fresh autumn plumage.

Specimens examined (12): South Brook, 1 ad. ♀, 5 juv., July 2–25, 1949; Salmonier, 2 ad. ♂, June 15, 1949; Doyles, 1 ad. ♂, 1 ad. ♀, 2 juv., June 23–August 27, 1959.

Hylocichla ustulata swainsoni (Tschudi). Swainson's Thrush

Newfoundland and Cape Breton Island Swainson's Thrushes have been separated by Burleigh and Peters (1948) as *clarescens* with type locality at Glenwood, Newfoundland. The original description is difficult to follow, due in part to nomenclatural misunderstandings that existed at the time. It appears to imply that the describers of *clarescens* regard it as intermediate in characters between birds breeding on the mainland from Labrador westward and birds inhabiting the northeastern United States. In other words, *clarescens* would appear to be intermediate between two 'extremes,' both ends of which are currently treated, and probably correctly so, as one and the same subspecies, *swainsoni*, in the A.O.U. Checklist of North American Birds (1957).

The writer (Godfrey and Wilk, 1948) has commented on the perplexing extent of individual variation in this species. Our Newfoundland series points up one of the dangers of relying on a small series. A small collection made in 1949 and 1950 in Newfoundland contains a preponderance of brownish-backed birds that resemble more rufescent specimens examined previously (Godfrey and Wilk, 1948) from Pennsylvania and the peninsula of Nova Scotia. Our larger 1959 series, on the other hand, contains a preponderance of olivaceous specimens like *swainsoni* from Labrador west.

At one time the writer (Godfrey 1951, p. 172) was inclined to recognize *clarescens*. This view was based on (1) the fact pointed out earlier (Godfrey

and Wilk 1948) that birds from the Maritime Provinces of Canada and those of eastern United States have a slight tendency to more brownish upper parts and a somewhat more intensive and extensive buffy wash on the breast compared with *swainsoni* from the Prairie Provinces, and (2) a small series of six Newfoundland birds, all that were available to me at the time, which were similar in appearance to birds from the Maritime Provinces.

Now, with a series of 27 Newfoundland specimens available for comparison with good collections of *swainsoni* from most parts of the breeding range in Canada, the validity of *clarescens* has been painstakingly re-examined. The larger Newfoundland series clearly shows the wide extent of individual variation in the Newfoundland population, the coloration of the upper parts varying from olivaceous to brownish or greyish. By no characters known to the writer can any satisfactory percentage be separated from *swainsoni*. Specimens in fresh autumn plumage taken on the putative breeding range of *clarescens* indicate the futility of trying to identify individuals outside the breeding range.

In the unlikely event that birds inhabiting Nova Scotia, Prince Edward Island, and the northeastern United States should prove separable from *swainsoni* they cannot be called *clarescens* because, as Burleigh and Peters (1948) have indicated, Newfoundland birds are more like those from the eastern mainland farther north. The writer has examined no recently taken specimens from the northeastern United States, but good series taken recently in Prince Edward Island and Cape Breton Island (Godfrey 1954, 1958) do not differ constantly enough from *swainsoni* to warrant separation from that race.

Newfoundland specimens examined (27): South Brook, 5 ad., July 9-25, 1949; Port Saunders, 4 ad., July 6-8, 1950; Port-aux-Basques, 1 ad., June 3, 1949; Doyles, 14 ad., 2 imm., June 24 - September 2, 1959; Topsail Pond, 1 imm., August 20, 1959.

***Hylocichla minima minima* (Lafresnaye). Gray-cheeked Thrush**

Wallace (1939), Burleigh and Peters (1948), and Todd (1958) have pointed out that Newfoundland breeding populations have more brownish upper parts than do northern continental populations. Wallace (1939) concluded that the type specimen of *Turdus minimus* Lafresnaye is a specimen of the Newfoundland breeding population, and Todd (1958) indicated the availability of the name *aliciae* Baird for the northern continental race. Examination of our additional Newfoundland specimens at once convinced the writer that they represent a readily-recognizable race. This race may not be confined entirely to Newfoundland, however.

Wallace (1939) examined three perplexing June and July adult males from Percé, Gaspé Peninsula, which are in the National Museum of Canada and have been examined by me. All have brownish upper parts. Two of them, with wing lengths of 93.5 mm, were referred by Wallace to *bicknelli* because of their small size. The third has a wing length of 100 mm, and although it was taken on June 14, Wallace considered it probably a stray or late migrant individual of the Newfoundland population. On July 12, 1955, we secured three additional adult males near Percé, all of which are large birds. Two have wing lengths of 98 and 101 mm, respectively; the other unfortunately had the extreme tips of the longest primaries on

both wings shot off, but the remainder of the wing measures 97 mm. Thus, four of six individuals from Percé are too large for *bicknelli* and too brown-backed for *aliciae*. This strongly suggests that the nominate race is not confined to Newfoundland. The writer has seen no material from the north shore of the Gulf of St. Lawrence.

Specimens examined (8): Port Saunders, 2 ad. ♂, 1 ad. ♀, June 30–July 11, 1950; South Brook, 2 ad. ♂, June 28–July 25, 1949; Table Mountain, 1 ad. ♂, July 15, 1959; Topsail Pond, 1 imm., August 20, 1959; Doyles, 1 imm., September 2, 1959.

***Hylocichla fuscescens fuliginosa* Howe. Veery**

Howe (1900a), after reaching the conclusion that Newfoundland Veeries were not separable, changed his mind within a year and described them as *fuliginosa* with type locality at Codroy. Noble (1919) and Bangs (1930) both were unable to recognize the race. It received little recognition until Burleigh (1944) and Peters and Burleigh (1945) re-affirmed its validity. I find it very poorly characterized, just barely worthy of recognition.

Anyone who examines adequate series of breeding Veeries from various parts of the breeding range on the mainland of eastern Canada will quickly encounter some extremely perplexing problems. Darker individuals of *fuliginosa* that closely resemble *fuliginosa* are not uncommon. Two colour phases occur, the commoner of which is tawny like most *fuliginosa* of north-eastern United States, the other a darker reddish brown. Puzzling colour mosaics add to the difficulties. Intergradation between *fuliginosa* and *salicicola* occurs over a large area extending from Rossport, Ontario, to Lake St. John, Quebec, across the northern periphery of the species range, an area that produces both *salicicola*-like and *fuliginosa*-like individuals and birds representing many stages of intergradation between the two. A small proportion of individuals of this intergrading population are not separable from *fuliginosa* by any characters known by the writer, although they are probably genetically different. Needless to say, the identification of migrants as *fuliginosa* should be attempted with extreme caution.

Although the A.O.U. Check-list (1957) extends the range of *fuliginosa* onto the mainland to Lake St. John, Quebec, the writer doubts, as a result of current studies being made as new material becomes available, that *fuliginosa* breeds anywhere on the mainland. Lake St. John birds are probably cut off from *fuliginosa* by a hiatus in the north (the species is not known to breed in Cape Breton Island, Prince Edward Island, or in the Gaspé Peninsula) and by *fuliginosa* in New Brunswick and the peninsula of Nova Scotia. Moreover, Lake St. John birds are different from *fuliginosa*.

A series of five June adults from Grindstone Island, Magdalen Islands, Quebec, recently collected at the writer's request by Austin W. Cameron and David Johnston, show clearly that *fuliginosa* is the breeding form there.

Specimens examined from Newfoundland (19): Tompkins, 1 ad. ♂, 4 ad. ♀, June 9–July 14, 1943; South Brook, 1 ad. ♂, 1 ad. ♀, June 5, 1942, July 6, 1949; Doyles, 4 ad. ♂, 1 ad. ♀, 7 imm., July 10, 1943, July 19, 1944, June 29–September 2, 1959. From Magdalen Islands, Quebec (5): Grindstone Island, 4 ad. ♂, 1 ad. ♀, June 18–25, 1959.

Dendroica petechia amnicola Batchelder. Yellow Warbler

This widely distributed and universally accepted subspecies was described by Batchelder (1918) with type locality at Curslet, Newfoundland. A fine series from Newfoundland differs from *aestiva* in having darker, more olivaceous (less yellowish) upper parts, although the occasional specimen approaches *aestiva* in the coloration of those parts.

Dendroica striata (Forster). Blackpoll Warbler

Burleigh and Peters (1948) have proposed the separation of birds breeding in western North America and northern Ungava and have named them *D. s. lurida*, the type specimen from Nushagak, Alaska. Godfrey (1952) and Parkes (1954), using different material, reached similar conclusions, namely that breeding adults from the western and eastern parts of the North American mainland are not significantly different.

Godfrey (loc. cit.), however, examined a small series of adult males from Newfoundland and noted slightly heavier and more extensive dorsal streaking in them. Now a fine series of 21 breeding adult males from Newfoundland supports this. Thus 13 of the 21 Newfoundland breeding males are separable by heavier dorsal streaking from 23 of a series of 36 comparable specimens from western Canada; and from 13 of a series of 17 from southern Quebec (Gaspé Peninsula, north shore of the Gulf of St. Lawrence, Lake Mistassini, Lake St. John). A series of eight breeding adult females from Newfoundland, on the other hand, does not appear to be significantly different from birds of the mainland, either eastern or western. The adult males, however, suggest an incipient Newfoundland race.

Our series of Newfoundland early autumn immatures in fresh first basic plumage is brighter (more yellowish, less olivaceous) and on the average has heavier dorsal streaking than 17 comparable birds from the Prairie Provinces. However, the Newfoundland series was recently taken (1959), and the western series is old, and at least some of the differences are perhaps due to differences in 'museum age.' A series from Mistassini Lake, Quebec, taken in 1947, is intermediate between these two series both in brightness and in 'museum age,' but it shows great individual variation in dorsal streaking.

Newfoundland specimens examined (53): South Brook, 3 ad. ♂, 4 ad. ♀, June 28–July 18, 1949; Salmonier, 1 ad. ♀, June 13, 1949; Port-aux-Basques, 1 ad. ♀, June 2, 1949; Port Saunders, 4 ad. ♂, July 1–11, 1950; Cape Anguille, 2 ad. ♂, July 4, 1959; Topsail Pond, 1 ad. ♂, 16 imm., August 12–26, 1959; Millville, 1 imm. ♂, August 27, 1959; Doyles, 12 ad. ♂, 2 ad. ♀, 3 imm., June 17–August 31, 1959; St. Andrews, 3 imm., August 25, 1959.

Seiurus aurocapillus furvior (Batchelder). Ovenbird

This well-marked race was described by Batchelder (1918) with type locality near Deer Pond, Newfoundland. It is readily separable from *aurocapillus* from the mainland (including Cape Breton Island and Prince Edward Island) by its darker and somewhat duller green back, scapulars, and rump; darker and more brownish crown patch; and, on the average, more extensive black stripes on the sides of the crown. The writer does

not see that the under parts are consistently different, however. Burleigh and Duvall (1952) examined two late May specimens from Tompkins and two autumn birds from Cape Anguille which were like *aurocapillus*, but all of our 18 specimens are definitely *furvior*. This subspecies appears to be confined to Newfoundland.

Specimens examined (18): South Brook, 3 ad. ♂, 2 ad. ♀, 1 imm., June 28–August 15, 1949; Millville, 1 imm., August 27, 1959; Doyles, 5 ad. ♂, 4 ad. ♀, 2 imm., June 23–September 4, 1959.

***Seiurus noveboracensis noveboracensis* (Gmelin).** Northern Waterthrush

Burleigh and Peters (1948) postulated the separation of Newfoundland birds as *uliginosus*, their type specimen taken at Topsail, Avalon Peninsula. While Newfoundland material is separable from *notabilis*, all attempts by the writer to separate it from the nominate race proved futile. The more olivaceous upper parts and yellowish under parts postulated for *uliginosus* are characters of the nominate race, the yellow of the under parts being perhaps better developed in a few individuals from Newfoundland than elsewhere. Anyone who has examined adequate series of Northern Waterthrushes will appreciate the large amount of individual variation in populations of the species, so well demonstrated by Eaton (1957). Our large series is no exception, but it shows clearly that Newfoundland breeding birds are best referred to the nominate race. Any other course would result in hopeless confusion.

Specimens examined (56): Doyles, 24; Topsail Pond, 15; Cape Anguille, 1; Tompkins, 1; South Brook, 8; Salmonier, 4; Port Saunders, 3.

***Geothlypis trichas brachidactyla* (Swainson).** Northern Yellowthroat

Oberholser (1948) proposed no less than 12 new subspecies from various parts of North America. The type locality of one of these, which he called *quebecicola*, is Balena, Newfoundland. It is difficult to draw any definite conclusions from our breeding material as all such specimens were taken in July and are worn and faded.

A good series in fresh basic plumage is available, however. They are on the average slightly darker greenish above than comparable birds from interior localities in Quebec and eastern Ontario and the under parts average slightly buffier (less whitish), the flanks slightly darker. However, as some similar individuals are to be found in the interior series, these differences are perhaps not significant.

I follow Peters and Burleigh (1951) in referring Newfoundland birds to *brachidactyla*. At the same time it should be pointed out that I have not been able to compare them with United States specimens of *brachidactyla* as restricted by Oberholser (1948).

Specimens examined (31): Doyles, 9 ad. ♂, 1 ad. ♀, 18 imm., July 7–September 7, 1959; Cape Ray, 2 ad. ♀, July 14, 1959; Tompkins, 1 imm., September 8, 1959.

***Euphagus carolinus nigrans* Burleigh and Peters.** Rusty Blackbird

This subspecies was described by Burleigh and Peters (1948), the type from Stephenville Crossing, Newfoundland. Parkes (1954) found no differences between Newfoundland breeding adults and those inhabiting

Quebec and Ontario but somewhat reluctantly recognized *nigrans* on the basis of darker brown feather edgings of the dorsum of adult males in fresh autumn plumage. Our breeding adults, like these examined by Parkes, show no consistent differences from Quebec and Ontario material. In fact, two of our three adult females in breeding plumage are paler than some individuals from Quebec. Our one adult male in fresh autumn plumage, however, has darker brown dorsal feather edgings as also has our one Nova Scotia (Greenfield, October 9, 1956) autumn male. Five autumn males from northern New Brunswick, while more variable, contain one male in almost complete first basic plumage (St. Leonard, August 1) that is similar to *nigrans*, three (near Bathurst, August 15–19) that are intermediate but closer to *nigrans* than *carolinus*, and one (Miscou Island, September 20) more like *carolinus*.

Specimens examined (10): South Brook, 2 ad. ♂, 1 ad. ♀, 1 juv. ♂, July 5–18, 1949; Salmonier, 1 ad. ♂, June 15, 1949; Port Saunders, 1 ad. ♀, July 7, 1950; Doyles, 1 ad. ♀, June 29, 1959; Topsail Pond, 1 ad. ♂, 2 imm. ♀, August 13–20, 1959.

***Carpodacus purpureus purpureus* (Gmelin). Purple Finch**

Burleigh and Peters (1948) proposed the separation of the Newfoundland breeding population as *C. p. nesophilus* (type from Stephenville Crossing), and this arrangement has been adopted in the A.O.U. Check-list of North American Birds (1957). The original description was based on a series of three adult males, four adult females, and two subadult males. This is scarcely an adequate series, considering the wide seasonal, sexual, and individual variation characteristic of the species.

The original description of *nesophilus* asserts that Newfoundland birds have "decidedly darker" upper parts in both sexes compared with the nominate race. Our ten breeding males do not show any tendency toward darker upper parts in comparison with 14 comparable males from southern interior Quebec and Ontario. In fact, the tendency, though slight, is just the opposite with the darkest individuals in the mainland series. Similarly the red coloration of throat and breast is darker in average in the mainland series (this a seasonally variable character, however). Females and subadults also show no significant differences, the Newfoundland birds being no darker and having about the same tendency to be olivaceous above. Also they show no significant differences in the whitish streaking of the dorsum. Slightly larger size attributed to Newfoundland birds is not significant, if indeed any difference exists at all. Wing length of ten adult males from Newfoundland measured by the writer averages 82.7 mm, compared with an average (of three) of 84.3 mm, measured by Burleigh and Peters. Their wing measurements of adult males and females average only a millimetre or less larger than those given for adult males and females of the nominate race by Ridgway (1901), while tail length of their Newfoundland adult males is actually shorter. Their measurements for the wing of subadult males (70 mm) is presumably a typographical error. The writer can see no grounds for recognizing *nesophilus* and refers Newfoundland birds to the nominate race.

Specimens examined (26): South Brook, 5 ad. ♂, 4 subad. ♂, 3 ad. ♀, 1 subad. ♀, June 28–July 28, 1949; Port Saunders, 2 ad. ♂, 1 ad. ♀, July 3–10, 1950; Doyles, 2 ad. ♂, 3 ad. ♀, 4 subad. unsexed, June 22–August 26, 1959; Highlands, 1 ad. ♂, July 1, 1959.

Pinicola enucleator eschatos Oberholser. Pine Grosbeak

Oberholser (1914) described this race, the type specimen of which was collected at Harry's River, Newfoundland. It is separable from *P. e. leucura* by its smaller dimensions and average slightly darker coloration. Griscom (1934) has diagnosed it so well that further comment on its Newfoundland aspects would be redundant. Its breeding range on the mainland extends roughly from southern Quebec and the Maritime Provinces south to central Maine and northern New Hampshire. Intergradation with *leucura* farther north and westward, however, requires additional study.

Since the time this race was originally described by Oberholser (1914), authors have consistently spelled the trinomial with a masculine ending (*eschatosus*). Its describer, Dr. Oberholser, when I recently brought the matter to his attention, quickly assured me that this was a *lapsus* in the original description. The feminine *eschatos* should be used to conform with the feminine gender of the genus *Pinicola* (so designated by its original describer, Vieillot).

Specimens examined (21): Port Saunders, 5 ad. ♂, July 1–10, 1950; South Brook, 2 subadult ♂, 1 subad. ♀, July 6–16, 1949; Doyles, 2 ad. ♂, 5 subad. ♂, 2 ♀, 2 subad. unsexed, June 23–July 30, 1959; Topsail Pond, 2 subad. ♂, August 20–21, 1959.

Loxia curvirostra pusilla Gloger. Red Crossbill

This well-marked race, readily distinguishable from the mainland subspecies *L. c. minor* (Brehm) by larger size and darker coloration, was first discovered by Bent (1912), who named it *perna*. Later, van Rossem (1934) found that the very old type specimen of *Loxia pusilla* Gloger is an example of the Newfoundland subspecies; consequently, the much older but less appropriate name *pusilla* Gloger must be used for the Newfoundland race. Our Newfoundland series is relatively uniform, clearly showing the characters of the Newfoundland subspecies. Griscom (1937), in his excellent monograph of this species, has ably treated this subspecies in detail.

Specimens examined (38): Salmonier, 5; South Brook, 3; Tompkins, 11; Doyles, 19.

Passerculus sandwichensis labradorius Howe. Savannah Sparrow

Aldrich and Nutt (1939) found a series of 13 specimens from southeastern Newfoundland (Avalon Peninsula) perfectly typical of *labradorius*. Our series of 26 breeding adults from the southwestern corner (Doyles, Highlands, Table Mountain, Cape Anguille) apparently are not so uniform. Eight specimens closely approach Nova Scotia *savanna*, although the remaining 18 are more like *labradorius*. This indicates intergradation toward *savanna* in southwestern Newfoundland, although that population as a whole is certainly nearer to *labradorius*. As Aldrich (1940) has pointed out, Nova Scotia birds have more brownish upper parts than birds from interior points within the range currently recognized for *savanna*.

Specimens examined (36): Doyles, 17 ad., 8 imm.; Cape Anguille, 5 ad.; Table Mountain, 2 ad.; Highlands, 1 ad.; Stephenville Crossing, 1 ad.; Topsail Pond, 1 imm.; Tompkins, 1 imm.

DISTRIBUTIONAL DATA

Anas discors subsp. Blue-winged Teal

Ouellet saw one that could fly only with difficulty, and he took it to be young. It was following two adult females at Upper Ferry, near Doyles, on July 2. This tends to confirm the suspicion of Peters and Burleigh (1951) that the species may breed in Newfoundland. No specimens were collected.

Circus cyaneus hudsonius (Linnaeus). Marsh Hawk

A single individual was seen at Doyles on July 28 and on September 4 and 5.

Falco sparverius sparverius Linnaeus. Sparrow Hawk

An immature female collected by Ouellet on September 4 at Doyles establishes the occurrence of the species in Newfoundland. The species was observed at Doyles on June 23 (1), 24 (1); July 29 (2); September 2 (1), and 6 (1). One was noted at Cape Anguille on July 3, and two at Upper Ferry on September 6.

Rallus limicola limicola Vieillot. Virginia Rail

One of the surprises of the 1959 expedition was the discovery that this rail is breeding in Newfoundland. It was thought to have been of casual occurrence heretofore. On July 21, four adults and two downies were seen near Doyles, of which one adult female and one downy were collected. Its breeding has been recorded from the Magdalen Islands, Quebec, by Philipp (1913).

Porzana carolina (Linnaeus). Sora

Two were observed near Doyles on July 2 and 21, but no specimens were taken. Peters and Burleigh (1951) regard its occurrence as casual.

Charadrius vociferus subsp. Killdeer

One was observed at Millville on August 27. Its occurrence is considered accidental by Peters and Burleigh (1951) who list three specimens and a sight record.

Philohela minor (Gmelin). American Woodcock

One was observed at Doyles on July 29.

Chaetura pelagica (Linnaeus). Chimney Swift

The only observation was of five at Codroy on July 3.

Empidonax traillii traillii (Audubon). Alder Flycatcher

Observed in the Doyles area on 13 dates in June and July, but no more than three were noted on any one day. At Stephenville Crossing, three were recorded on July 9. Two specimens were secured at Doyles.

Vireo solitarius solitarius (Wilson). Solitary Vireo

An adult, accompanied by two juvenals, was observed at Doyles on July 29. The two juvenals were collected. Although obviously they were out of the nest for some time, the rectrices are not quite fully developed

and there are traces of sheaths still about the remiges. This strengthens the theory of Peters and Burleigh (1951) that a few may nest in Newfoundland.

Vermivora peregrina (Wilson). Tennessee Warbler

According to Peters and Burleigh (1951) this warbler is rare, occurring mainly in western Newfoundland. In the southwestern part, however, our party did not find it rare. About Doyles they observed it on June 19 (5), 20 (3), 21 (3), 22 (3), 23 (8), 24 (4), 26 (3), 27 (2), 28 (1), 29 (2); July 1 (1), 5 (2), 7 (3), 8 (1), 11 (2), 14 (1), 15 (1), 16 (1), 18 (2), 20 (1); August 29 (1), September 4 (1), 5 (1). At Tompkins four were noted on June 25, and one on September 8. One was seen at Millville on August 27 and on September 8. Specimens were taken at Doyles (3 ad. ♂, 1 imm. unsexed, July 8–September 5); Millville (1 imm., August 27); Tompkins (1 imm., September 8).

Dendroica tigrina (Gmelin). Cape May Warbler

An unsexed bird of the year, collected at St. Andrews on August 25, 1959, by Ouellet, is the first record for Newfoundland.

Agelaius phoeniceus phoeniceus (Linnaeus). Redwinged Blackbird

Although this species has not been reported previously from Newfoundland, it was first observed by L. M. Tuck (MS.) who saw a male in a cat-tail marsh near Stephenville from June 18 to 20, 1955. Our 1959 party observed 18 some three miles northeast of Doyles on July 2, 1959, and eight there on July 21. At Stephenville Crossing they noted ten on July 9. Six fledglings were collected, some of which had tails just beginning to unsheath, thus establishing the breeding of the species there. Apparently this species is confined to the southwestern corner of the island, and probably it is a recent arrival.

Specimens examined (12): Doyles (3 miles northeast), 2 ad. ♂, 1 subad. ♂, 3 ad. ♀, 6 juv., July 2–21, 1959.

Molothrus ater subsp. Brown-headed Cowbird

Ouellet and McNeil observed ten at Doyles on July 2 and five at Bay Bulls on August 4, 1959, but did not secure a specimen. This species was first recorded for Newfoundland (where it appears to be a recent arrival), by Baird and Emery (1957, p. 390) who gave details of a banded bird taken at Remea on April 21, 1957. Additional records are included in the summary of the distribution of this bird in the Atlantic Provinces by Mills (1957). Its occurrence in Newfoundland was not known to Peters and Burleigh (1951).

Pheucticus ludovicianus (Linnaeus). Rose-breasted Grosbeak

An adult male was observed by our party at Doyles on June 21, 1959. Peters and Burleigh (1951) had only one Newfoundland record, a male taken at Tompkins on May 24, 1947.

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NOTES ON CANADIAN MAMMAL SPECIMENS AND TYPES IN THE BRITISH MUSEUM (NATURAL HISTORY), LONDON

By A. W. F. BANFIELD

INTRODUCTION

The collections of the British Museum (Natural History) are of great importance to mammalogists because of the wealth of mammal types and the historically important specimens which they contain. During a recent visit to the Museum (from June 6 to 23, 1959), I tried to find (and photograph them in colour) all the types of Canadian mammals contained there. In addition, an attempt was made to trace and list as many as possible of the early specimens obtained on expeditions to northern Canada during the nineteenth century.

I am indebted to Dr. F. C. Fraser, Keeper of Zoology; Dr. Peter Crowcroft, and Messrs. R. W. Hayman, J. E. Hill, and G. W. C. Holt, of the Mammal Section; and Miss King of the Skeleton Section, for their co-operation and assistance in the project.

Before listing the specimens, some notes on their sources and on the methods of cataloguing them are necessary. Much valuable information obtained on this subject by Oldfield Thomas (1906) was used as a starting point. Prior to 1838, specimens were given a species number; individual specimens of a species were noted as *a*, *b*, *c*, and so forth. The type specimen was usually labelled *a*. Those numbers are referred to as old numbers in this report. During the period 1838 to 1937, specimens were catalogued by decade, and by year, month, day, and number accessioned on that day (i.e. 38.10.12.5). In addition, skulls were often catalogued separately in the skeleton collection.

There were many important institution collections presented to the Museum, such as the Zoological Society of London Collection (55.12.24.1 to 370 *ca.*) in 1855, the Hudson's Bay Company Collection (44.11.5.1 to 28 etc.), and private collections of Sir John Richardson, Selous (19.7.15.1 to 448 etc.), and G. S. Miller (7.7.7.1 to 3,000 *ca.*). Most of these specimens were already numbered in their groups.

In some cases, type specimens were not designated in the early descriptions. Oldfield Thomas (1927) picked a few lectotypes from some of the early specimens studied by the authors. Others have been designated as types long ago and are not registered in the general collection. The types are presently kept together in a type collection. I found a few types still unrecognized in the general collection and brought them to the attention of the staff.

A total of 31 type specimens were located, and 25 were photographed on Ektachrome 4 x 4 cm film. The transparencies are available in the Zoology Section, National Museum of Canada, for study.

The following annotated list of Canadian specimens was obtained from the mammal collection registers. Many of the early specimens were known to have been destroyed. Those found are marked with an asterisk, and notes on their importance follow in parentheses.

REGISTERED SPECIMENS

A number of mammals from North America presented by Thomas Drummond and later discarded as worthless (Oldfield Thomas, 1906):

- 37.521. *Lupus* Arctic regions. R. King (probably Back's expedition, 1836)
- 522. *Lepus* (possibly mentioned by Drummond, 1830)
- 523. *Sciurus*
- 524. *Phoca*

Collections presented by Dr. J. Richardson from North America:

- 37.12.9.8. (skull) *Mus leucopus* Richardson. Fort Franklin.
- 9. (skull) *Arvicola* Richardson
- 10. *Mustela cichonia* Richardson
- 11. (skull) *Putorius hudsonicus* Richardson
- 12. *Ursus americanus* (very young) Richardson. Lake Huron.
- *42.10.7.1. *Sorex palustris* Richardson (type)
- *2. *S. forsteri* Richardson (type)
- 3. *Tamias quadrivittatus*
- 4. *Spermophilus franklinii*
- 5. *S. richardsonii*
- *6. *Neotoma drummondii* (type)
- 7. *Arvicola riparius*
- 8. *A. xanthrognathus*
- 9. *A. noveboracensis*
- *10. *A. borealis*. Fort Franklin (type)
- *11. *Georychus helvolus* (type)
- *12. *Lagomys princeps* (type)
- *13. *Georychus trimucronatus* (type)
- 42.12.9.2. *Mustela* (?) Great Slave Lake. Sir J. Richardson 63b Sabine
- 3. ? *americana* Carlton House. Apr. 16, 1827, 63c Sabine
- 4. ? Carlton House. Apr. 15, 1827. 63d
- 5. ? Rocky Mts. (Drummond Coll.) 63d
- 6. *Arctomys pruniosus* (mounted skin)
- *7. *Pteromys sabrinus* (first referred specimen)
- *8. ditto (labelled *volucella*=*volans*)
- 9. *Mustela vison* (to Dundee Museum 1892)
- *10. *Arctomys empetra* 94f=c. (*S. undulatus parryi*)
- *11. *Arctomys empetra* 94g (*S. undulatus parryi*)
- 12. ditto another? 202b Bachman (*S. columbianus*)
- 13. ditto 202c Dr. Green
- 14. *A. franklini* 61c
- 15-17. *Sciurus hudsonicus*
- 18. *Tamias lineatus* Richardson 61b (species 61 was *S. franklini*)
- 19. ?
- *20. *Arctomys hoodii* (female) May 12, 1827. Carlton House. 62b
- 21. *Arvicola riparius*

The old numbers, 61*b* etc., indicate that the specimens were duplicates of the Sabine ground squirrels described in 1822. Numbers 2 to 6 are listed as *Mustela*; they perhaps should have been listed as *Marmota* according to the old number 63, which was *Spermophilus richardsonii*. Specimen 7, labelled *sabrinus* Richardson, unfortunately lacks a locality. It might have been the type to *alpinus* Richardson (1829). Otherwise it is the first specimen referred to *sabrinus* of Shaw (1801).

There was considerable confusion in the early use of *empetra*. The specimens located from this collection were *Spermophilus undulatus parryi*. Others elsewhere were *Marmota monax*.

It seems unfortunate that Howell (1915) rejected the trivial name *pruinosa* of Pennant (1784) and Richardson (1828) for the hoary marmot. From an examination of early specimens, it is clear that Richardson and other explorers used both the scientific and vernacular names to consistently identify the form we now know as *Marmota caligata* Eschscholtz (1829).

North America:

*43.3.3.3. *Mustela longicauda* J. Richardson

*4. *M. richardsoni*

*5. *M. cicognani*

Gray has indicated on the catalogue that those are the types of the Bonaparte (1838) three species.

North America:

*43.7.20.43. *Tamias striatus* (purchased)

*45. ditto ditto

Specimens presented by the Hudson's Bay Company:

43.11.28.1. Buffalo

2,3. Jumping deer (*Antilocapra*) decayed, skull only

4. Reindeer (*R. tarandus*)

5. Black bear (*U. americanus*) Albany Dist.

6. Lynx

7. Wolverine (*Gulo borealis*) Albany Dist. Mr. James Heron

8. Otter (*Lutra canadensis*) ditto ditto

9. *Mustela* (*Vison lutrecephala*) ditto ditto

North America:

*44.7.4.8. *Tamias striatus* Coll. Dr. Stevens

44.11.5.1-5. *Rangifer tarandus*

6, 7. *Lutra canadensis*

8. ?

9,10. *Gulo luscus*

11. *Ursus americanus*

12. *Erethizon dorsatum*

13-15. *Lepus arcticus*

16, 17. *Sciurus hudsonicus*

18. *Sorex*

19-24. *Myodes hudsonius*

Specimens presented by the Hudson's Bay Company:

- 44.11.5.25. *Arvicola*
 26. ?
 27. *Arvicola riparius*
 28. *Canis familiaris* (Eskimo dog)
- 45.7.4.3,4. *Cervus (columbianus)* (skull; tail short, tipped with black)
 5. *C. (virginianus)* (tail long, underside and tip white)
 6. ditto (skull)
 7. *Lepus americanus* (skull, white)
 8. *L. americanus* (skull, white)
 *9. *Arctomys pruniosus* (skull, whistler)
 10. *Taxidea labradoria*
 11. *Martes pennanti*
 12. *Canis*
 13,14. *Vulpes* (white)
 15. *Lynx canadensis*
 16,17. *Vison lutreola*

Specimens from the John Rae expeditions:

- *48.3.13. 1. *Spermophilus parryi* (label reads Hudson's Bay)
 2. *Myodes trimucronatus*
 3,4. *M. helvolus*
 5-9. *M. groenlandica*
 10-12. *Mus musculus*
- *49.1.30.2. *Spermophilus richardsoni* 63d (flat skin, skull 17059)
- 51.9.24.1. *Spermophilus parryi* (Capt. Kellett)
- 52.11.30.1. *Vespertilio* (Fort Pilby)
 2. *Mus* (ditto)
 3. *Meriones* (ditto)
 4. *Rupicapra americana* (ditto)
 (*Haploceras montanus*)
- 55.5.14.1. *Rangifer tarandus* (skin)
 2. ditto (skeleton)
 3. ditto (skin)
 4. *Ovibos maschatus* (skin)
 5. ditto (skeleton)
 6. ditto (skin)
 7. ditto (skeleton)
 8. ditto (skeleton)
 9. *Ursus*
 10. *Canis lupus* (skin)
 11. ditto (skeleton)
 12. *Ursus* (skeleton)
 13. *Gulo bussus* (skin)
 14. ditto (skeleton)
 15. *Lepus arcticus* (skin)
 16. ditto (skeleton)
 17. ditto (skeleton)

18-20. <i>Arctomys</i>	(skin)
21,22 ditto	(skeleton)
23. <i>Phoca</i>	(skeleton)

Specimens presented by the Zoological Society of London (Several of these specimens would be types if they still existed.):

North America:

- *55.12.24.92. *Sorex parvus*. Richardson (1829) type
- 105. *Sciurus leucotes* (black variety) Z.S.L.
- 107. *S. carolinensis*. Dr. Bachman Coll.
- 110. *S. Douglasii*. Douglas Coll.
- 117. *Neotoma Drummondii* Columbia. Richardson 1829, p. 137
- 119. *Lagomys princeps*. type Waterhouse 1839
- 122. *Spermophilus phaeognatha*. Hudson's Bay. type—Bennett 1833 (see Richardson 1829, p. 161)
- *125. *Arctomys flaviventer* Bachman. type
- *126. *A. pruniosus*. Rockies. Back exped. - type *okanaganus*
- 204. *Arvicola rutilus*. Hudson's Bay
- 205. *Geomys umbrinus*. (type) Richardson 1829
- 206. *G. talpoides*. Hudson's Bay (type) Richardson 1829
- 363. *Mus leucopus*. United States
- 369. *Scalopus breweri*
- 370. *S. townsendi*

Specimens presented by J. K. Lord, International Boundary Commission 1859-60, from Vancouver Island:

- 60.2.20.2. *Vison* (skin) collector's number 8
- 3. *Pteromys* ditto 4
- 4. *Sciurus hudsonicus* var. *douglasi* 5
- 5. ditto *richardsoni* 1
- 6. ditto ditto 2
- 7. *Tamias asiaticus townsendi* 7
- 8. *Mus* 3
- 9. ditto 9
- 10. ditto 6
- 60.11.19.1. *Fiber zibethica*. Sumas, B.C.
- 2. *Lagomys princeps* (male). Cascade Mts.
- 3. *Pteromys volucella* (female). Chilliwack
- 4. ?
- 5. *Mus*. Vancouver Island
- 6. *Neotoma drummondii* (male). Chilliwack Lake, Cascade Mts.
- 7-9. *Sciurus hudsonicus douglasi* (male). Chilliwack
- 10. *Tamias asiaticus townsendi* (female). Sumas Prairie, B.C.
- 11. ditto ditto ditto (male) ditto
- 12,13. *Procyon lotor* (male) ditto
- 14. *Tamias asiaticus townsendi* (female) ditto
- 15. *Canis* (skull) Fort Langley
- 68. *Neurotrichus gibbsi*. Sumas and Chilliwack River
- 69-73. *Hesperomys leucopus*. Sumas
- 74-76. *Sorex* ditto

Part of a collection of 47 mammals from Fort Simpson and Fort Halkett, N.W.T. presented by B. R. Ross:

- 61.5.27.1. *Lepus americanus* (skin)
- 2-9. *Sciurus hudsonicus* (ditto)
- 10-11. *Arvicola riparius* (ditto)
- 12-17. *Hesperomys myoides* (ditto)

Specimens collected by J. K. Lord from Stikene Indians of north Vancouver Island:

- 62.6.22.1. Indian
- 2. *Enhydra foetus*
- 3,4. *Castor canadensis*
- 5. *Mustela americana*
- 6-9. *Mus leucopus*
- 10. *Castor*
- 11. *Thomomys douglasi*
- 62.12.12.15,16. *Lagomys princeps*
- *19. *Perognathus monticola* (type *P. lordi* Gray)
- 31. *Castor*
- 62.12.30.3. *Fiber zibethicus* (skin). Fort Coville R.
- 4. ditto (ditto). Fraser R.
- 5. ditto (ditto). Columbia R.
- *6,7. *Fiber osoyoosensis* B.C.
- 8. *F. zibethicus*
- 9,10. *Lagomys princeps*. W. slope cascades. Exchange Paris 1882
- *11. *L. minimus*
- 12. *Mustela erminea*

Further specimens collected by B. R. Ross, Fort Halkett, N.W.T.:

- 63.1.6.10. *Arvicola riparius*
- 11. *Hesp. leucopus*
- 12. *Synap. cooperi*
- 13. *Sorex*
- 63.1.13.1. *Lepus americanus* Mackenzie R.
- 2. *Neotoma cinerea* Fort Liard
- 3. *Tamias quadrivittatus* San R.
- 4. *Hesp. leucopus* Ft. Simpson
- 5,6. *Arvicola riparia* ditto
- 7. ditto Anderson R.
- 8. *A. xanthrognathus* (skin) Ft. Simpson
- 9. *A. gapperi*. Lapierre's H. (Fort Macpherson)
- 10. *A. richardsonii* Ft. Simpson
- 11. *Putorius cicognani*

*63.2.24.18. *Spermophilus lateralis*. J. K. Lord

Further specimens collected by B. R. Ross at Fort Simpson, N.W.T.:

- 63.10.28.1. *Mustela erminea*
- 2. *Lutra canadensis*
- 3,4. *Arvicola xanthrognathus*
- 5,6. *A. rutilus*
- 7,8. *A. riparius*
- 9-11. *Sorex*
- 12. *Talpa*
- 63.10.29.1. *Spermophilus* (no loc.)
- 2. *Arvicola riparius* (ditto)
- 3. *A. rutilus*
- 4. *Sorex*

A few mammals were found in the general collection which had not been assigned register numbers after 1838. These were as follows:

- *102a, b. *Spermophilus empetra*. Sir J. Back (*S. undulatus* collected between 1833-35)
- 131a. *Tamias lateralis*. Sir J. Richardson. Rocky Mts.

TYPE SPECIMENS

(The nomenclature and order follow that of Hall and Kelson, 1959.)

***Sorex cinereus cinereus* Kerr**

1828. *Sorex Forsteri* Richardson, Zool. J., 3(12):516.

Holotype. No. 42.10.7.2 B.M.(N.H.), old No. 255a, collected by Thomas Drummond (original label number 14) between 1825 and 1827, sex unknown.

Type Locality. Probably along the North Saskatchewan or Athabasca rivers in Alberta or Saskatchewan.

Condition. Mounted specimen, skull included, exposed tooth row indicates it is *cinereus*, tail broken, pelage foxed and faded.

Remarks. The common long-tailed shrew of northern Canada was first described by Forster (1772) and later by Pennant (1784), but Kerr (1792) first assigned a scientific name. Richardson (1828) re-described Forster's shrew and gave it a scientific name. There was no type specimen designated, but the following year in *Fauna Boreali Americana* he described this specimen in detail as *Forsteri*. The specimen is labelled "small shrew mouse Drummond" and according to the catalogue was the only one available, which makes it in effect the holotype.

It is not known where along Drummond's route the specimen was secured, but he reported collecting extensively at Carlton House, Saskatchewan, in the summer of 1827, and several other types are known to have been taken then (Drummond, 1830).

***Sorex palustris palustris* Richardson**

1828. *Sorex palustris* Richardson, Zool. J., 3(12):517.

Lectotype. No. 42.10.7.1 B.M.(N.H.), old number 254a. Sex unknown. Collected by Thomas Drummond (original number 15).

Type Locality. Probably along the North Saskatchewan River, Alberta or Saskatchewan.

Condition. Mounted specimen, belly fur slipped, summer pelage, chin greyish but underparts generally olive-brown. Skull lacks cranium.

Remarks. The label reads "Large shrew mouse Drummond," indicating that the specimen was taken by Drummond somewhere along his route during 1825 to 1827. Since the specimen does not have the pale greyish underparts of *navigator*, it was probably not taken in the Rocky Mountains. Drummond (1830) mentions collecting at Carlton House, Saskatchewan, in the summer of 1827, when the specimen may have been secured.

Richardson (1828, 1829) did not designate a type specimen, but from the catalogue it appears certain that this is the only specimen extant which Richardson had.

***Sorex fumeus fumeus* Miller**

1895. *Sorex fumeus* Miller, North Am. Fauna No. 10, p. 50, Dec. 31, 1895.

Holotype. No. 7.7.7.2582. B.M.(N.H.), adult female, collected by Gerrit S. Miller (collector's number 2582), on Sept. 24, 1893

Type Locality. Peterboro, Madison Co., New York.

Condition. Skin in good condition, worn summer pelage, skull complete.

Remarks. Measurements (mm): total length 116, tail 44, hind foot 12.6, ear 8.4.

***Sorex arcticus arcticus* Kerr**

1837. *Sorex richardsonii* Bachman, J. Acad. Nat. Sci. Philadelphia, 7, part 2, p. 383.

Holotype. No. 55.12.24.92. B.M.(N.H.), old number 89, Zool. Soc. London Mus. Sex unknown, adult.

Type Locality. Label reads "North America," probably somewhere along the North Saskatchewan or Athabasca rivers of Alberta or Saskatchewan.

Condition. Mounted, pelage foxed and faded, but dark back and pale flanks of winter pelage of *arcticus* clearly discernible.

Remarks. Richardson (1829) incorrectly identified the specimen as *Sorex parvus* Say = *Cryptotis parva*, based upon the literature. He did not think his specimen was related to *araneus* of Forster (1772) because of the well-furred ears. Bachman (1837) based his description upon this specimen. Since Kerr's names have no types, this specimen is the first referred to the valid name.

***Ochotona princeps princeps* (Richardson)**

1828. *Lepus (Lagomys) princeps* Richardson, Zool., J. 3(12):520, April, 1828.

Lectotype. No. 42.10.7.12. B.M.(N.H.), old number 93b, collected by Thomas Drummond (original number 6) probably in 1826. Sex unknown. Presented by Sir J. Richardson.

Type Locality. Near Athabasca Pass at the head of the Whirlpool River, Jasper National Park, Alberta (Howell, 1924).

Condition. Study skin somewhat darkened by dirt, skull fragmentary, mandibles and rostrum only.

Remarks. Richardson gave the range as the Rocky Mountains and mentioned examining specimens from region of Fort Nelson, B.C., as well as specimens killed by Drummond and one in the Hudson's Bay Company Museum. Howell (1924) restricted the type locality to Athabasca Pass.

The present specimen has the following information on its label "rough stones in the mountains Drummond (*buckathrae kah-yawzae* MacPherson)." The latter phrase may be translated from some Indian language as "little-chief hare" according to Richardson (1829). Undoubtedly he got the information from Murdoch MacPherson. It is the only specimen extant to be considered as the type.

Measurements (mm): hind foot 27, ear 19.

***Ochotona princeps fenisex* Osgood**

1863. *Lagomys minimus* Lord, Proc. Zool. Soc. London 1863, p. 98.

Holotype. No. 62.12.30.11. B.M. (N.H.), collected by J. K. Lord, autumn 1860 (?), sex unknown, skull No. 1443a.

Type Locality. Ptarmigan Hill, Ashnola River, Cascade Range, B.C. (Howell, 1924).

Condition. Well-prepared study skin, buffy cheeks and shoulders, dark back, pale belly.

Remarks. Originally described by Lord as *Lagomys minimus*. Renamed *Ochotona fenisex* by Osgood (1913). Reduced to subspecific rank by Howell (1924).

***Marmota flaviventris flaviventris* (Aud. and Bach.)**

1841. *Arctomys flaviventris* Audubon and Bachman, Proc. Acad. Nat. Sci. Philadelphia, 1:99.

Holotype. No. 55.12.24.125. B.M.(N.H.), from the Zool. Soc. London Mus., collector David Douglas, sex unknown, adult.

Type Locality. Mount Hood, Oregon. Restricted by Howell (1915).

Condition. Study skin, without skull.

Remarks. Howell referred to the type specimens under *Remarks*. A note by Oldfield Thomas on the label reads "matched by specimens from the Cascades."

***Marmota caligata okanagana* (King)**

1836. *Arctomys okanagana* King, Narr. Jour. to shores of Arctic Ocean, Vol. 2, p. 236.

Holotype. No. 55.12.24.126. B.M.(N.H.), collected by R. King. Skull probably No. 58.5.4.437.

Type Locality. Gold Range, B.C. Restricted by Howell (1914).

Condition. Study skin in fair condition except for the tail. Identity of skull questionable.

Remarks. The specimen was brought alive to Norway House and eventually taken to England where it lived some time in the London Zoological Gardens. After death it was preserved in the museum. The locality erroneously reported on the label was Norway House, north end of Lake Winnipeg.

Spermophilus richardsonii richardsonii (Sabine)

1822. *Arctomys richardsonii* Sabine, Trans. Linn. Soc. London 13(2): 589.

Lectotype. No. 63a. B.M.(N.H.), old number, collected by Sir J. Richardson in 1820, adult, sex unknown.

Type Locality. Carlton House, Saskatchewan.

Condition. Flattened study skin, greasy, skull in skin.

Remarks. Lectotype selected by Oldfield Thomas (1927).

Spermophilus tridecemlineatus tridecemlineatus (Mitchill)

1822. *Arctomys hoodi* Sabine, Trans. Linn. Soc. London 13(2): 590.

Lectotype. No. 62a. B.M.(N.H.), collected by Sir J. Franklin, probably in 1820.

Type Locality. Carlton House, Saskatchewan.

Condition. Study skin in fair condition, dirty, faded; skull lacks mandibles, and the zygomatic arches are broken.

Remarks. Curiously there is a second specimen No. 42.12.9.20. (old number 62b) in the register, labelled as type of *hoodi*. It was taken by Sir J. Richardson on May 12, 1827, at Carlton House. Of course it could not be the type of Sabine's (1822) *hoodi*. Howell (1938) placed *hoodi* in synonymy under *tridecemlineatus*.

Spermophilus franklinii franklinii (Sabine)

1822. *Arctomys franklinii* Sabine, Trans. Linn. Soc. London 13(2): 587.

Lectotype. No. 61a. B.M.(N.H.), probably collected by Sir John Richardson in 1820, adult male.

Type Locality. Carlton House, Saskatchewan.

Condition. Study skin in good condition. Rump, hind legs, and tail darkened by grease. Skull complete, back of cranium broken.

Remarks. The type locality was restricted by Preble (1908).

Thomomys talpoides talpoides (Richardson)

1828. *Cricetus talpoides* Richardson, Zool. J. 3(12): 518.

Holotype. No. 55.12.24.206. B.M.(N.H.), presented by the Zool. Soc. London.

Type Locality. Carlton House, Saskatchewan.

Condition. Study skin very dark chocolate, lighter brown on shoulders, skull fragmentary, rostrum and maxillary teeth, mandibles with right broken.

Remarks. Label reads "Dr. Richardson, Hudson's Bay," undoubtedly the specimen referred to by Richardson (1828). He mentions the species at Carlton House, and Bailey (1915) restricted the type locality to that location. There is also another specimen, No. 55a, consisting of a rostrum alone, labelled *Geomys borealis*, Canada, Richardson. Richardson (1837) later renamed his species, believing *talpoides* to be invalid, but *borealis* is generally now treated as a synonym (Bailey, 1915).

Perognathus parvus lordi (Gray)

1868. *Abromys lordi* Gray, Proc. Zool. Soc. London, 1868, p. 202.

Holotype. No. 62.12.12.19. B.M.(N.H.), collected by J. K. Lord, in 1859 or 1860.

Type Locality. Similkameen River, British Columbia.

Condition. Study skin rather dirty with dark streaks on the back; the skull lacks mandibles, and zygomatic arches are rather poorly cleaned.

Remarks. Treated as a species by Osgood (1900); reduced to subspecies by Davis (1939).

Castor canadensis leucodontus Gray

1869. *Castor canadensis leucodonta* Gray, Ann. Mag. Nat. Hist. ser. 4, 4:293.

Lectotype. No. 68.3.19.5. B.M.(N.H.), collector Dr. Brown (field No. 496B).

Type Locality. Northwest corner of Vancouver Island, B.C.

Condition. Skull only, No. 68.3.19.5 has zygomatic arches broken.

Remarks. Teeth are creamy white (probably caused by cleaning agent, according to Oldfield Thomas, 1927). Lectotype picked by Oldfield Thomas (1927).

Neotoma cinerea drummondii (Richardson)

1828. *Myoxus drummondii* Richardson, Zool. J. 3(12):517-518.

Holotype. No. 42.10.7.6. B.M.(N.H.), probably collected by Thomas Drummond in 1825 to 1827, female, presented by Sir J. Richardson.

Type Locality. Jasper, Alberta.

Condition. Study skin, pelage slipped on head, and tail moth-eaten, skull with broken rostrum and zygomatic arches.

Remarks. The label reads "Rocky Mountains latitude 57°, Dr. Richardson." Richardson (1828) mentioned the specimen in the Zool. Soc. London collection as having a defective tail which fits the present specimen. Although this specimen is the first recorded in the registers, there was another listed from the Zool. Soc. London, No. 55.12.24.117, which might have been the type but was not located. The specimen is certainly one of those listed by Richardson (1829, p. 138). Measurements (mm): hind foot 38, ear 26.5.

Microtus chrotorrhinus chrotorrhinus Miller

1894. *Microtus chrotorrhinus* Miller, Proc. Boston Soc. Nat. Hist., 26:190.

Holotype. No. 7.7.7.2522. B.M.(N.H.). Presented by G. S. Miller, Jr. Adult female collected July 14, 1893.

Type Locality. Head of Ti ravine (Tuckerman's Ravine), Mount Washington, Coos Co., N.H.

Condition. Study skin and skull in excellent condition.

Remarks. Measurements (mm): total length 165, tail vertebrae 45, hind foot 19.4, ear 13.8.

Ondatra zibethica osoyoosensis (Lord)

1863. *Fiber osoyoosensis* Lord, Proc. Zool. Soc. Lond. 1863, Pt. 1 and 2, pp. 95–98.

Lectotype. No. 62.12.30.6 B.M.(N.H.), collected by J. K. Lord in 1859 or 1860, skull No. 1442a.

Syntype. No. 62.12.30.7. B.M.(N.H.), skull No. 1442b, collected at the same time, is smaller.

Type Locality. Osoyoos Lake, British Columbia.

Condition. Type study skin in good condition, skull No. 1442a, left zygomatic arch broken, left mandible and back of skull missing.

Remarks. The specimens were found in the general collection unrecognized as types. No. 62.12.30.6 is here designated as the lectotype. Measurements (mm): total length 490 *ca.*, tail vertebrae 220 *ca.*, hind foot 75, ear 18.

Skull measurements are as follows:

	No. 1442a	No. 1442b
Greatest length.....	59.0	58.3
Zygomatic breadth.....	—	34.5
Least orbital width.....	16.2	16.1
Height of skull.....	22.3	22.7
Nasal length.....	18.9	18.5
Maxillary tooth row.....	14.4	14.1
Bullae width.....	25.8	—
Diastema.....	20.4	20.2
Incisive foramen.....	11.8	12.3

Lemmus trimucronatus helvolus Richardson

1828. *Arvicola (Lemmus) helvolus* Richardson, Zool. J. 3 (12):517.

Holotype. No. 42.10.7.11. B.M.(N.H.), collected by Thomas Drummond in 1825 or 1826, presented by Sir J. Richardson.

Type Locality. Near the headwaters of one of the southern branches of the Peace River in British Columbia or Alberta.

Condition. Small study skin, very tawny, skull fragments—rostrum and mandibles.

Remarks. The label reads “Loc alpine swamps latitude 56°.” During the summer of 1826, Drummond travelled north from Jasper House to the headwaters of the Peace River (Drummond, 1830). The specimen was probably secured near the northern limit of his trip, since no specimens have been taken in Alberta.

Although no type was designated in 1828, Richardson (1829) did specify this specimen, which was apparently the only one available.

Lemmus trimucronatus trimucronatus (Richardson)

1825. *Arvicola trimucronata* Richardson, in Parry, Journal of a second voyage . . . app., p. 309.

Holotype. No. 42.10.7.13. B.M.(N.H.), collected by Capt. Back in 1820 or 1821.

Type Locality. Point Lake, Coppermine River, Mackenzie District, N.W.T.

Condition. Study skin, good condition, quite orange, skull fragmentary—mandibles, maxillary tooth row and rostrum only.

Remarks. Presented by Sir J. Richardson. The present specimen is described in Richardson (1829).

Synaptomys borealis borealis (Richardson)

1828. *Arvicola borealis* Richardson, Zool. J. 3(12):517.

Holotype. No. 42.10.7.10. B.M.(N.H.), collected by Sir J. Richardson during the winter of 1825-26.

Type Locality. Fort Franklin, Mackenzie District, N.W.T.

Condition. Study skin remade from mounted specimen, in fair condition, including tail. Skull missing.

Remarks. Notes on the label "four inches long exclusive of tail, mouse A, page 12 note-book awinak Dog-ribs." This was the only specimen available at that time to be considered as the type.

Canis lupus arctos Pocock

1935. *Canis lupus arctos* Pocock, Proc. Zool. Soc. London 1935, p. 682.

Holotype. No. 55.11.26.74. B.M.(N.H.), taken on Sir E. Belcher's expedition of 1853 to 1854. Probably male.

Type Locality. Melville Island, Franklin Dist., N.W.T.

Condition. Complete skull only.

Canis lupus orion Pocock

1935. *Canis lupus orion* Pocock, Proc. Zool. Soc. London, 1935, p. 683.

Holotype. No. 97.3.5.1. B.M.(N.H.), probably male.

Type Locality. Cape York, Northwest Greenland, Baffin Bay.

Condition. Skin from old mount, dirty grey; skull lacks cranium.

Mustela erminea arctica (Merriam)

1904. *Putorius audax* Barrett-Hamilton, Ann. and Mag. Nat. Hist. 13 (ser. 7):392.

Holotype. No. 78.6.26.5. B.M.(N.H.), collected by H. C. Hart.

Type Locality. Discovery Bay, Ellesmere Island, N.W.T.

Condition. Study skin, pale and faded; skull lacks occipital wall.

Remarks. Considered a synonym for *M.e. arctica* by Hall (1951).

Mustela erminea cicognanii Bonaparte

1838. *M. cicognanii* Bonaparte, Charlesworth's Mag. Nat. Hist., 2, p. 37.

Holotype. No. 43.3.3.5. B.M.(N.H.), presented by Sir J. Richardson, a female.

Type Locality. North America, probably Carlton House, Saskatchewan.

Condition. Very small faded, foxed summer skin, skull fragmentary—rostrum and mandibles.

Remarks. Although noted in the catalogue by Gray to be the type of Bonaparte's name, Hall (1951) presents many good reasons for not accepting it as the type.

Mustela erminea richardsonii Bonaparte

1904. *Putorius arcticus emperii* Barrett-Hamilton, Ann. and Mag. Nat. Hist., 13 (ser. 7):392.

Holotype. No. 63.10.28.1. B.M.(N.H.), collected by B. R. Ross.

Type Locality. Fort Simpson, Mackenzie District, N.W.T.

Condition. A large summer skin, skull lacks posterior wall of cranium.

Remarks. Preble (1908) considered this name as a synonym of *M. richardsoni*.

Mustela erminea richardsonii Bonaparte

1838. *Mustela richardsonii* Bonaparte, Charlesworth's Mag. Nat. Hist. 2:38.

Holotype. No. 43.3.3.4. B.M.(N.H.), collected by Sir John Richardson, probably at Fort Franklin during the winter of 1825-26.

Type Locality. Fort Franklin, Mackenzie Dist., N.W.T.

Condition. Mounted specimen on pedicel, winter pelage, skull lacking.

Remarks. Although Gray stated in the catalogue that this was Bonaparte's type, Hall (1951) has pointed out the problems in assuming that this was the specimen collected by Richardson at Fort Franklin.

Mustela frenata longicauda Bonaparte

1838. *Mustela longicauda* Bonaparte, Charlesworth's Mag. Nat. Hist., 2:38.

Holotype. No. 43.3.3.3. B.M. (N.H.), collected by Sir J. Richardson.

Type Locality. Carlton House, Saskatchewan.

Condition. Study skin remade from mounted specimen, winter pelage, skull complete.

Remarks. See Hall (1951) for discussion of accepting the specimen as the type.

Phoca vitulina richardii (Gray)

1864. *Halicyon richardii* Gray, Proc. Zool. Soc. London, 1864, p. 28.

Holotype. No. 1861.10.9.8. B.M.(N.H.), skeleton collection No. 1431a.

Type Locality. Vancouver Island, British Columbia.

Condition. Complete skeleton, skull lacks only jugals.

Remarks. Kept in skeleton collection.

Rangifer tarandus osborni J. A. Allen

1935. *Rangifer montanus selousi* Barkley, Proc. Zool. Soc. London, 1935, p. 306.

Holotype. No. 7.3.11.1. B.M.(N.H.), collected by Selous, adult bull.

Type Locality. South Fork, MacMillan River, southeast Yukon Territory.

Condition. Whole mounted animal, much faded by exhibition.

Remarks. Specimen found in old exhibition hall unrecognized as type, labelled *osborni*. It was treated as a synonym of *osborni* by Hall and Kelson 1959.

Ovibos moschatus wardi Lydekker

1908. *Ovibos moschatus melvillensis* Kowarzik, Zool. Anzeiger, 33:617.

Holotype. Old number 612a. B.M.(N.H.), collected by Commander E. Parry in 1820.

Type Locality. Melville Island, Franklin District, N.W.T.

Condition. Study skin, tanned, in excellent condition, muzzle whitish, greyish saddle, long dark hairs elsewhere, no skull located.

Remarks. Considered a synonym for *wardi* by Allen (1913). The skeleton and skull on which Kowarzik based his description may be in the skeleton collection which was not searched.

Ovibos moschatus wardi Lydekker

1900. *Ovibos moschatus wardi* Lydekker, Nature, 63:157.

Co-type. No. 0.12.1.1. B.M. (N.H.). Obtained from taxidermist Rowland Ward.

Type Locality. Clavering Island, East Greenland.

Condition. Mounted specimen in excellent condition.

Remarks. This specimen was found in the Exhibition Section laboratory. It is the mount of a young specimen.

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NOTES ON THE MAMMALS OF THE KLUANE GAME SANCTUARY, YUKON TERRITORY

BY A. W. F. BANFIELD

The Kluane Game Sanctuary, comprising an area of approximately 10,000 square miles, is situated in extreme southwestern Yukon Territory. Alaska and the 60th parallel of latitude form its western and southern boundaries, and the valleys of Kluane Lake and the White River form its northern boundary. About two-thirds of the area is composed of the glacier-clad St. Elias Mountains. The northern tundra-clad foothills, situated in a moisture shadow of the higher southern peaks, constitute excellent big game range because of their limited annual snowfall. The boreal forest extends up the outer slopes and valleys to about 3,800 feet. This spectacular area is also a National Park reserve.

The big game and fur-bearer resources of the Sanctuary were investigated for the Canadian Wildlife Service during the month of June, 1951. A second brief visit was paid to the area on May 29, 1955. The Sanctuary was first reached via the Alaska highway on June 4, 1951. After a short stay at Kluane Lake, the interior of the Sanctuary was explored by pack train from the 6th to the 19th. The route led up the Donjek River, Wolverine Creek, Tepee Lake, St. Clair River, Klutlan Glacier, White River, and the highway was reached again via Edith Creek. On the 21st and 22nd, the highway was patrolled as far as White River; the Haines road was traversed on the 22nd and 23rd. I returned to Whitehorse on the 24th and arranged for an aerial survey of big game ranges of the Sanctuary, which was conducted on June 28.

Other accounts of the mammals of the area, notably those of Baker (1951) and Cameron (1952) dealt largely with the taxonomy of the smaller mammals. The present account merits recording in view of the fact that it deals at greater length with the status of the larger species found in the interior of the Sanctuary. Clarke (1943) prepared a manuscript report on an early visit to the area.

During my investigations, small mammal populations were at a low ebb in the sanctuary in contrast to conditions when the other workers visited the area. During the month, only 18 specimens of five species were secured in 300 trap-nights.

Notes on the birds observed have previously been recorded (Banfield, 1953).

ANNOTATED LIST

Cinereus Shrew *Sorex cinereus cinereus* Kerr

Four specimens were taken at Tepee Lake, June 14 and 15, and two at Edith Creek summit, June 17 and 18. The average measurements (mm) were: total length, 85; tail, 36; hind foot, 12; and ear, 7. They were found along the stream-beds above timberline and in mossy spruce woods.

Grizzly Bear *Ursus arctos*

Grizzly bear signs were common on the Donjek River flats on June 8 and 9, where the bears had been digging *Hedysarum* roots. Tracks were also noted at Wolverine Creek, Tepee Lake, and the Klutlan River. I saw no grizzlies in the Sanctuary, although the Indian wrangler saw two while searching for the horses on the Donjek flats. The number of their tracks led me to conclude, however, that they were common and were widely distributed. During the early summer they were feeding on the river bottoms. Neither bears nor their tracks were seen on the tundra. A skull picked up at the Duke River was donated by Mr. Joe Langevin. One bear was seen at Kusawa Lake, June 28.

Black Bear *Ursus americanus*

Only one black bear track was noted on the trail ascending Wolverine Creek, June 10. It seemed to be less common in the sanctuary than along the Alaska Highway, where it is reported to be a nuisance about settlements and camps.

Timber Wolf *Canis lupus*

The only sign of wolves noted during the investigation was one track observed on the Wolverine Creek trail on June 10.

Several outfitters along the Alaska Highway, including Mrs. Jacquot of Burwash Landing, had sustained losses of horses from wolf predation during the winter months. It was supposed that large packs of wolves inhabited the sanctuary. However, when the Director of Game and Publicity gave a permit to Archie Lampman of Burwash Landing to poison wolves in the Sanctuary during the preceding two winters, only one wolf was killed.

When Mr. Joe Langevin, Kluanè Warden, accompanied Lampman on a winter patrol into the Sanctuary, they saw only one wolf track during the trip on the upper Wolverine Creek.

From these observations, it was concluded that timber wolves were scarce in the Sanctuary.

Coyote *Canis latrans*

A coyote track was observed at Tepee Lake. My guide told me that there were a few coyotes in the area.

Fox *Vulpes vulpes*

Fox tracks were very common along the shore of Tepee Lake, June 11 to 15. There were numerous locations where foxes had dug out ground squirrels (*Spermophilus parryi plesius*). The local scarcity of those animals was thought to be the result of predation by foxes.

Pine Marten *Martes americana*

The guide reported that there were a few in the Sanctuary. He secured two the previous season on the Kluanè River north of the Sanctuary.

Short-tailed Weasel *Mustela erminea*

While hunting pikas on Edith Creek Pass on June 18, I observed a weasel scurrying among the boulders of a talus slope, engaged in the same occupation.

Mink *Mustela vison*

Reported by the Indians as occurring in the Sanctuary.

Otter *Lutra canadensis*

Messrs. Cameron and Kendall reported seeing two otter on their canoe trip down the Koidern River, June 5, 1950. They expressed some concern that otters were common in the valley and thought that they were a threat to beaver and muskrat propagation.

Wolverine *Gulo luscus*

The fresh tracks of a wolverine were noted on the trail ascending to Edith Creek summit on June 17. The guide reported that they were common in the Sanctuary.

Lynx *Lynx canadensis*

The guide reported that while accompanying his uncle, Jimmy Joe, on his trapline in the present Sanctuary area in 1942, they snared a lynx on Cement Creek, a tributary of the Donjek River.

Hoary Marmot *Marmota caligata*

No marmots were observed during the investigation, although a considerable amount of time was spent above the treeline. My guide reported that a few occur in Sergeant's Pass.

Ground Squirrel *Spermophilus parryi plesius* (Osgood)

These squirrels were abundant above timberline throughout the Sanctuary and in open dry meadows and river flats at lower elevations. They are an important summer source of food for predatory animals and birds. Specimens were secured at Kluane Lake, Wade Creek, Tepee Lake, and the Haines Road. They are absent in the northwest portion of the Sanctuary where there are many sphagnum bogs underlain by permafrost.

Yukon Chipmunk *Eutamias minimus caniceps* Osgood

The chipmunk was commonly observed along the Alaska Highway as far as the Duke River, and along the Haines Road as far as Dezadeash Lake. None was observed, however, on the pack trip to the interior. It seems likely that they are confined to the forests and clearings of the lower elevations and do not extend far into the Sanctuary.

Red Squirrel *Tamiasciurus hudsonicus petulans* Osgood

Abundantly distributed throughout the forested regions of the Sanctuary. One specimen secured at Wade Creek, June 9.

Beaver *Castor canadensis*

Beaver signs and a dam were located on a small pond west of Tepee Lake. Two lodges were also observed through field glasses on the Koidern River. During a canoe trip down the Koidern River on June 5, 1950, Messrs. Kendall and Cameron observed 12 beaver and much old beaver sign.

White-footed Mouse *Peromyscus maniculatus algidus* Osgood

One white-footed mouse was taken in a clearing at Wade Creek, June 10. The tail of a second was left in a trap at Edith Creek. This region is near the northwest boundary of the range of the species.

Red-backed Vole *Clethrionomys rutilus dawsoni* Merriam

These voles were widely distributed throughout the spruce forests, and in stream banks and willow thickets above treeline. Specimens were taken at the following localities: Wade Creek: 1, June 9; Wolverine Creek: 1, June 11; Tepee Lake: 2, June 14, 15; Edith Creek summit: 1, June 18. Average measurements (mm) were: total length, 132; tail, 31; hind foot, 19; ear, 17. On three occasions during the pack trip, red-backed mice were observed running through the ground vegetation alongside the horses' feet.

Long-tailed Vole *Microtus longicaudus vellerosus* Allen

Two specimens of this vole were secured from tundra runways at the Haines Road summit, B.C., immediately south of the Sanctuary.

Muskrat *Ondatra zibethica*

One muskrat was watched cutting sedges on the shore of a pond in the Koidern valley on June 20. A close inspection of several of the ponds showed muskrat activity.

Porcupine *Erethizon dorsatum*

Unmistakable signs of porcupine feeding were noted on a balsam fir on the Donjek River flats on June 9. The Indians reported that porcupines were fairly common on the Sanctuary.

Collared Pika *Ochotona collaris*

Pikas were widely and commonly distributed in rock talus slopes on the steep mountain sides above treeline. Six specimens were taken from above Tepee Lake, June 12 and 15, and at Edith Creek summit on June 18. The average measurements (mm) were as follows: total length, 177; hind foot, 31; ear, 22. A good character to identify this species seems to be the creamy-buff fur patch on the side of the face over the facial gland. In *princeps* of the Rocky Mountains, this patch is rusty brown in colour.

A prevalent subcutaneous infection of cysticerei was found, which is probably the larval stage of a tapeworm found in the short-tailed weasel. Fleas collected were sent to Mr. George P. Holland, who has identified them as *Monopsyllus toli*, a species formerly known only from Siberia.

In a talus above Edith Creek, a pika den was discovered on June 18. The nesting cavity was in a crevasse between boulders. The floor and a

large refuse pile at the entrance were composed of *Dryas* leaves and seed heads, and *Carex* cuttings. Numerous faeces indicated prolonged and recent occupancy.

Varying Hare *Lepus americanus*

The population of hares was locally at a low ebb in the Sanctuary during the investigation. Only two hares were seen: Kluane Lake, June 5, and on the Haines Road, June 23; and signs of their occurrence were also rare.

Moose *Alces alces*

Although only three moose were seen during the investigation of the Sanctuary (Tepee Lake, June 12; Harris Creek, June 16; and Mush Lake, June 28), abundant signs of tracks and browsing along the trails indicated a population of moderate size. The signs were most abundant in the forested areas, but evidences of feeding and tracks were also observed on the tundra. In some areas the browsing on *Salix* amounted to moderate utilization. Had the animals been less wary, undoubtedly more would have been seen.

Discarded antlers were found in the Donjek, Wolverine, and Harris Creek valleys, indicating winter occupancy.

Other moose were seen from the air at Fish Lake and Kusawa Lake, east of the Sanctuary, on June 28.

Osborn Caribou *Rangifer* sp.

Only three animals were seen; two adult bulls, Klutlan Glacier, June 16, and one adult cow, Edith Creek summit, June 18. Fresh tracks observed on the trail at the following localities indicated, however, a wider summer distribution: Wade Creek summit, Wolverine Creek, Tepee Lake, St. Clare Creek, and Edith Creek. Shed caribou antlers were observed at Tepee Lake, Harris Creek, and St. Clare Creek.

During the summer months caribou range over the alpine tundra generally. In the Sanctuary their range extends south to the White River, Edith Creek summit, Sergeant's Pass, Wade Creek summit, and the St. Elias glaciers. In the winter months they are reported to descend to the wooded valleys. The St. Clare and Harris creek valleys are favourite haunts. In the height of the fly season they are reported to frequent the broad gravel beds of the river bottoms. My guide reported seeing 50 caribou on the St. Clare flats in August 1948. He estimated that the total population in the Sanctuary might be as high as 100 animals, a liberal figure judging from the scant evidence we observed.

The Kluane Sanctuary seemed to be one of the last strongholds of the Osborn mountain caribou in the Yukon. Two caribou were reported to have been killed by Indians north of Kluane Lake during the winter of 1950-51. Other reports of this subspecies were received from Marsh Lake, the mountains above Swift River, and Teslin Lake, 1950.

Stone's Caribou *Rangifer* sp.

Clarke (1943) reported the incursion of migratory barren-ground caribou to the Sanctuary during the winter of 1936-37. There was a report during the winter of 1950-51 of a small band of about 25 Stone's caribou which crossed the White River from the west, north of the Alaska Highway.

White Sheep *Ovis dalli*

The northeastern slopes of the St. Elias Mountains have long been known as a stronghold of the white sheep.

During the summer months, the sheep were distributed upon the higher alpine tundra slopes, green ledges, and talus slopes. In the Sanctuary, sheep were seen at the following localities: north of Mush Lake, June 28; Slim's River, eastern mountain shoulders, June 4 and 28; Sheep Creek, June 4; mountain east of Duke River, June 28; Mountain west of Donjek River, June 9; mountain south of Wolverine Creek, June 11; mountains north of Tepee Lake, June 11 to 15; about Edith Creek, June 18 and 19. My guide reported, in addition, that sheep were present in summer above the Kathleen Lakes, south of Duke River, at the head of Halfbreed Creek, Cement Creek, Lynx Creek, Sergeant's Pass, and St. Clare Creek. At that time of year the sexes were segregated; the rams frequented the highest alpine slopes, while the ewes, lambs, and yearlings tended to occupy lower grassy ledges and talus slopes.

In winter the sheep are reported to descend to the outer ranges of the St. Elias Mountains, where the snowfall is less. Favourite winter ranges are as follows: above Silver Creek, Sheep Mountain down to the Highway,

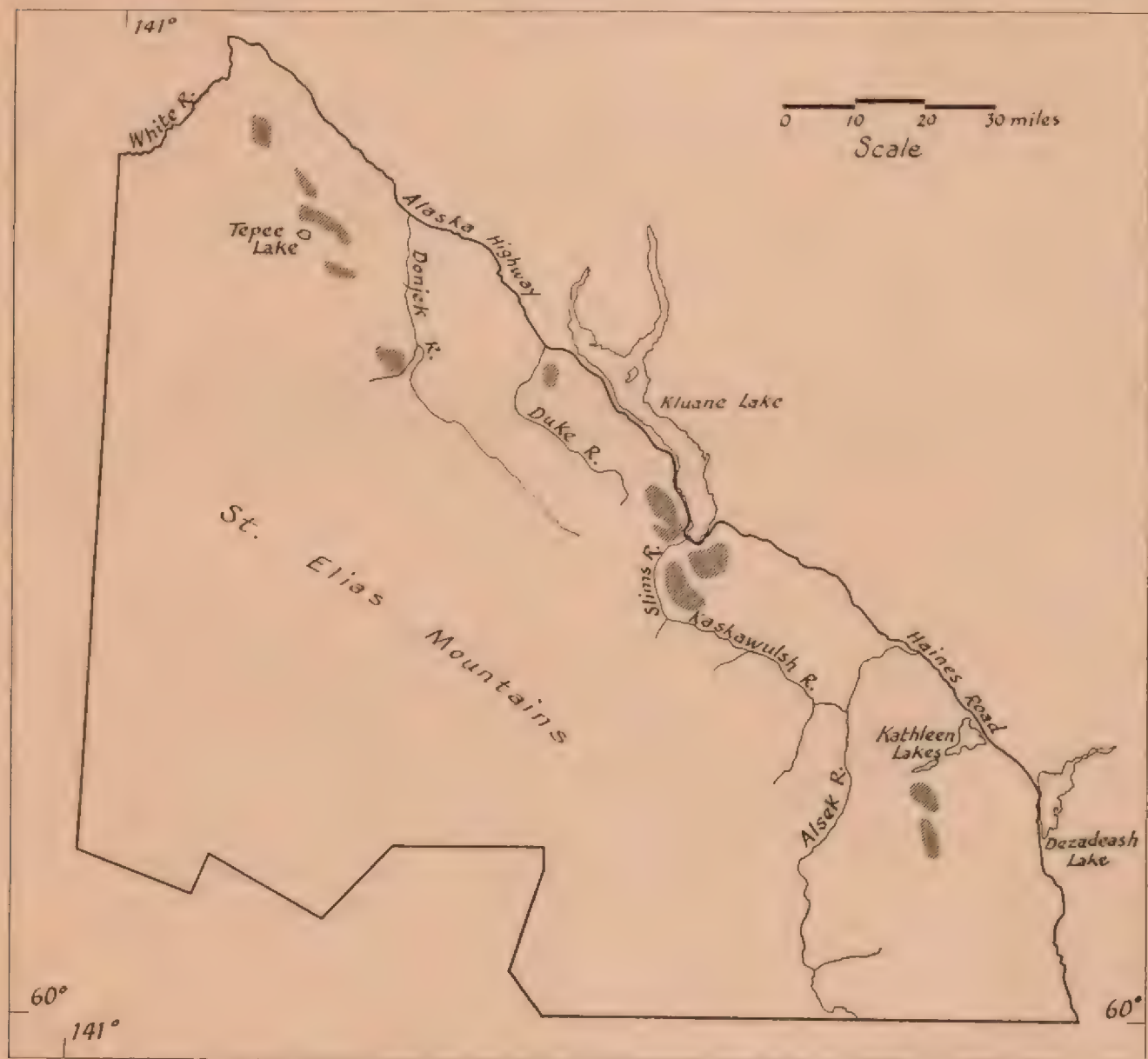


FIGURE 1.—Distribution of white sheep in the Kluane Sanctuary.

the mountains and benches north of Wolverine Creek between Lynx Creek and the Donjek River, and above the lower reaches of Edith and Hazel creeks. Many of these slopes are reported to blow free of snow in the winter. Accompanied by Warden Langevin, I examined, on foot, the Sheep Mountain winter range in detail on June 21. The range was composed of grassy slopes and benches, with groves of spruce and fir trees in canyons and pockets. The grass cover was moderately good. Other forage genera were *Arctostaphylos*, *Vaccinium*, *Shepherdia*, and *Artemisia*. The plants indicated xerophytic alpine conditions. There was abundant sign of winter sheep occupancy, but nowhere did the vegetation show signs of excessive utilization. Langevin reported counting 43 sheep on this range during the winter. I observed four rams high on the mountain shoulder. We saw no carcasses and thought predation was light.

A classified count of sheep made during the investigation, the majority of which were rams, is given in Table 1. The few ewe groups observed were seen at great distances, and a complete segregation was seldom possible. The small sample suggests a satisfactory annual increment and should provide an increasing population under the local conditions.

TABLE 1
Sheep Observations

Band	Date	Rams	Ewes	Lambs	Yg.	Unclassified
	June					
Sheep Creek.....	4	12	—	—	—	—
Donjek River.....	9	—	—	—	—	33
Wolverine Creek.....	10	—	5	3	2	—
Tepee Lake.....	11	14	1	—	—	—
	15	17	2	1	2	6
Edith Creek.....	18	—	10	5	3	—
Mush Lake.....	28	—	—	—	—	5
Slim's River (ewes +).....	—	—	—	—	—	70
Duke River (ewes +).....	—	—	—	—	—	30
Total.....	221	43	18	9	7	144

It is doubted that the white sheep are suffering from much wolf predation at present. As reported previously, wolves are scarce in the Sanctuary. Furthermore, an inspection of occupied sheep ranges failed to produce signs of predation. The habitat chosen by the sheep was rugged and precipitous. Most bands seen were close to ideal escape terrain in the form of rock faces. This was especially true of the ewe and lamb bands, which were often observed on inaccessible ledges. It seems that the white sheep are seldom vulnerable to wolf predation except when crossing valleys or on the lower benches of the winter range. The fact that sheep occupy these benches at the mouth of Sheep Creek in itself suggests that wolf predation is light.

During the investigations, several observations upon golden eagle white sheep relations led me to conclude that these birds are an important predator upon white sheep lambs (Banfield, 1953).

I was interested to note that upon my arrival in the Yukon in early June the white sheep lambs were already about a month old, although when I left Jasper at the end of May, no lamb bighorns (*Ovis canadensis*) had yet been observed.

I found that the white sheep were extremely wary, although they nominally had eight years of sanctuary. On two occasions above Tepee Lake, stalks were interrupted by a slight change in wind direction, which caused bands of rams to catch my scent. In both cases the rams fled, not stopping until they had gone over the mountain shoulder.

On our flight to the Sanctuary from Whitehorse on June 28, we observed bands of about 50 sheep, including ewes and lambs, on Primrose Mountain, and on the mountaintop east of Kusawa Lake we saw about ten rams outside the Sanctuary (see Figure 1 for distribution within the Sanctuary).

On May 29, 1955, 95 sheep were counted from the highway on Sheep Mountain. Warden Langevin reported that the sheep population, then totalling 200, had shown a steady increase since 1951.

Mountain Goat *Oreamnos montanus*

According to local reports, mountain goats in the Sanctuary are confined to the valley of the Alsek River. On June 28, six goats were seen from the air on a mountain west of the Alsek River. Numerous game trails were observed along the shale talus slopes north of the Kaskawulsh River, but these may have been other sheep or goat trails. Goats were reported as being common on the Haines Road summit in British Columbia, south of the Sanctuary. Although no goats were observed here on June 22 and 23, their trails and tracks were observed. The most easterly range of goats in southwest Yukon is reported to be Mount White, east of Marsh Lake.

Small mammal populations were found to be at a low ebb in the Sanctuary during the investigation. This is in marked contrast to conditions described by Clarke (1943). During the month only 18 specimens of five species (*Tamiasciurus*, *Peromyscus*, *Clethrionomys*, *Microtus longicaudus*, and *Sorex cinereus*) were trapped in 300 trap-nights.

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